

Appendix G6

**Air Quality - Health Risk Analyses of Construction and
Operating Emissions - Toxic Air Contaminants**

**G6-1 Health Risk Analysis - Toxic Air Contaminant
Emissions from Onshore Diesel Construction
Equipment**

**G6-2 Health Risk Analysis - Toxic Air Contaminant
Emissions from Operational Activities**

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Appendix G6-1
Health Risk Analysis
Toxic Air Contaminant Emissions from Onshore Diesel Construction Equipment
Cabrillo Port LNG Deepwater Port Project

1 INTRODUCTION

The objective of the health risk analysis was to evaluate the cancer risk and non-cancer acute and chronic hazard indices due to toxic air contaminants (TAC) emissions from diesel equipment used during onshore Project construction. Cancer risk and acute and chronic hazard indices due to the TAC emissions were estimated for representative locations in proximity to each construction activity.

2 METHODOLOGY

In the health risk analysis, potential ambient TAC concentrations at locations in proximity to Project construction activities were predicted using the United States Environmental Protection Agency (USEPA’s Industrial Source Complex-Short Term Model (ISCST3). These predicted ambient TAC concentrations were then used to estimate long-term (chronic) and short-term (acute) health risks associated with Project operations.

3 DISPERSION MODEL INPUTS

3.1 Emission Sources

Health risk impacts were evaluated for the following onshore construction activities:

- Installation of the Center Road Pipeline in Ventura County, including:
 - trenching
 - pipelay
 - boring
- Installation of the Line 225 Pipeline Loop in Los Angeles County, including:
 - trenching
 - pipelay
 - drilling
- Horizontal Directional Boring (HDB) at the pipeline shore crossing point at Ormond Beach in Ventura County

Trenching and pipelay would progress over pipeline routes of approximately 14 miles in Ventura County and approximately 7 miles in Los Angeles County. Thus, trenching and pipelay represent “moving” construction sites. Drilling and boring operations would occur at several locations in Los Angeles County and Ventura County, respectively, with the duration of construction at each location expected to vary. Shore crossing construction at Ormond Beach is expected to occur over a period of approximately 60 days.

A summary of the construction equipment associated with trenching, pipelay, and boring activities is presented in Table 1. A summary of the construction equipment associated with drilling and shore crossing HDB is presented in Table 2. Each piece of equipment included was included in the ISCST3 model run input. Each individual piece of construction equipment (or vessel) was input as a point source into ISCST3. The exhaust flow rate of each device was derived from the listed engine size and operating load. Stack height, exit diameter, and exit temperature were estimated for typical equipment. Stack parameters used for point sources are summarized in Tables 14 through 20 of Appendix G1-1 of the Final EIS/EIR.

3.2 Emission Rates

Maximum hourly TAC emission rates and average 24-hour TAC emission rates were developed for each source. Diesel particulate matter (DPM) is listed as a TAC. DPM emission rates for diesel-fueled equipment were set equal to the corresponding PM₁₀ emission rates for diesel-fueled equipment, excluding fugitive dust (see Appendix G1-1 of the Final EIS/EIR). The non-DPM TAC emission rates were calculated based on fuel input and published emission factors. Non-DPM TAC emission factors and overall maximum non-DPM TAC emission rates for each type of construction activity are presented in Table 3. The maximum hourly and 24-hour average emission rates of total non-DPM TAC by individual equipment used in trenching, pipelay, and boring are summarized in Table 4. Maximum hourly and 24-hour average emission rates of total non-DPM TAC by individual equipment used in drilling and shore crossing HDB are summarized in Table 5.

3.3 Receptors

For all activities except shore crossing HDB, a receptor grid was generated that extended up to 1,000 meters from the edge of the proposed construction areas. Receptor spacing was 25 meters up to a distance of 100 meters from the construction area; 50 meters between 100 meters and 200 meters from the construction area; and 100 meters beyond 200 meters from the construction area.

For shore crossing HDB, a receptor grid was generated that included all shore-based receptors that were located within 1,600 meters of the edge of the proposed construction area as presented in *California Environmental Quality Act Air Quality Impact Assessment of the BHP Cabrillo Deepwater Port LNG Import Terminal* (Sierra Research 2006) (see Appendix G7-1 of the Final EIS/EIR). Receptor spacing was 100 meters.

3.4 Meteorological Data

The ISCST3 model was run with one year of meteorological data that corresponds to the location of each construction activity. For activities that would occur in Ventura County, data from the El Rio Meteorological Station (Year 1991) was used. For activities that would occur in Los Angeles County, data from the Newhall Meteorological Station (Year 1981) was used. A summary of data used is presented below:

- Ventura County (El Rio, 1991)
 - Trenching
 - Pipelay
 - Boring
 - ShoreHDB
- Los Angeles County (Newhall, 1981)
 - Trenching
 - Pipelay
 - Drilling

3.5 Model Runs

For evaluation of acute health risks, maximum 1-hour ambient concentrations of non-DPM TACs were predicted using ISCST3 model runs maximum hourly emission rates. As there are no acute health risk indicators currently identified for DPM, maximum DPM emission rates were not used in this analysis. Model runs incorporated the total emission rate of all non-DPM TACs. The model results for total non-DPM TACs was then proportioned into each individual TAC accordingly.

Due to the relatively short duration of construction activities, annual ambient concentrations of DPM and non-DPM TAC were estimated by extrapolating from shorter term average ambient concentrations as described below:

Pipelay and Trenching. Annual ambient concentrations were estimated by assuming these construction activities would impact any given receptor for 5 days. Thus, a 5-day ambient average concentration was calculated as the average of the 5 highest 24-hour ambient concentrations (from ISCT3 model runs using 24-hour average emission rates). The annual average concentration was then assumed to equal the 5-day average concentration multiplied by a factor of 0.0137 (5 days / 365 days). Separate model runs incorporated (i) DPM and (ii) total non-DPM TACs. The model results for total non-DPM TACs were then proportioned into each individual TAC accordingly.

Boring and Drilling. Annual ambient concentrations were estimated by assuming these construction activities would impact any given receptor for 30 days. Thus, a 1-month ambient average concentration was calculated from ISCT3 model runs using 24-hour average emission rates. The annual average concentration was then assumed to equal the 1-month average concentration multiplied by a factor of 0.082 (30 days / 365 days). Separate model runs incorporated (i) DPM and (ii) total non-DPM TACs. The model results for total non-DPM TACs were then proportioned into each individual TAC accordingly.

Shore Crossing HDB. Annual ambient concentrations were estimated by assuming these construction activities would impact any given receptor for 60 days. Thus, a 1-month ambient average concentration was calculated from ISCT3 model runs using 24-hour average emission rates. The annual average concentration was then assumed to equal the 1-month average concentration multiplied by a factor of 0.164 (60 days / 365 days). Separate model runs incorporated (i) DPM and (ii) total non-DPM TACs. The model results for total non-DPM TACs were then proportioned into each individual TAC accordingly.

4 RISK AND HAZARD

Cancer risk was evaluated by calculating the cumulative maximum individual cancer risk (MICR) of all TACs emitted from onshore construction activities. Non-cancer acute and chronic health risks were evaluated by calculating the cumulative chronic hazard index (HIC) and cumulative acute hazard index (HIA) of all TACs emitted from Project sources. The MICR, HIC, and HIA for each individual TAC were estimated using calculation procedures outlined in *Risk Assessment Procedures for Rules 1401 and 212* (SCAQMD 2005) and *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* (OEHHA 2003). The equations used to calculate MICR, HIC, and HIA are described below.

$$\text{MICR} = \text{CP} \times \text{AveConc} \times \text{AF}_{\text{annual}} \times \text{DBR} \times \text{EVF} \times \text{MP}_{\text{cancer}} \times 10^6 \quad (\text{Eq } 1)$$

$$\text{HIC} = (\text{AveConc} \times \text{MP}_{\text{chronic}}) / \text{Chronic REL} \quad (\text{Eq } 2)$$

$$\text{HIA} = \text{PeakConc} / \text{Acute REL} \quad (\text{Eq } 3)$$

Where:

CP = cancer potency factor (mg/kg-day) $^{-1}$
 $AveConc$ = average annual concentration ($\mu\text{g/m}^3$)
 AF_{annual} = annual adjustment factor
 DBR = daily breathing rate (l/kg body weight-day)
 EVF = exposure value factor
 MP_{cancer} = multi-pathway factor [cancer]
 $Chronic\ REL$ = chronic reference exposure level ($\mu\text{g/m}^3$)
 MP_{chronic} = multi-pathway factor [chronic]
 $PeakConc$ = maximum 1-hr average concentration ($\mu\text{g/m}^3$)
 $Acute\ REL$ = chronic reference exposure level ($\mu\text{g/m}^3$)

The values of CP, MP_{cancer} , Chronic REL, MP_{chronic} , and Acute REL are unique to each individual TAC. Acute REL and Chronic REL are used as indicators of potential adverse non-cancer health effects. For this analysis, RELs are concentration levels, analogous to an inhalation reference concentration, at which no noncancer adverse health effects are anticipated. CP is a measure of the cancer potency of a carcinogen and is analogous to an inhalation slope factor. When available, RELs and CPs are obtained from the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA). REL and CP values were not available from OEHHA for some of the individual PAHs. The REL and CP values for these PAHs were based on inhalation reference doses and slope factors obtained from USEPA Region 9 Preliminary Remediation Goal (PRG) Tables (USEPA 2004).

MICR and HIC were calculated by assuming all receptors were categorized as residential/sensitive. Thus, the values of AF_{annual} , DBR, EVF, MP_{cancer} , and MP_{chronic} were set accordingly.

The values for AF_{annual} , DBR, EVF are listed in Table 6. The values for CP and MP_{cancer} are listed in Tables 7 and 8. The values for Chronic REL and MP_{chronic} are listed in Tables 9 and 10. The values for Acute REL are listed in Tables 11 and 12.

5 RESULTS

A summary of the maximum 1-hour concentrations for total non-DPM TACs and the 24-hr average and/or monthly average concentrations for DPM and total non-DPM TACs predicted from ISCST3 runs is presented in Table 6. Annual average concentrations (AveConc) for individual TACs were calculated from these model results (see Tables 7 through 10). Maximum 1-hour concentrations (PeakConc) for individual TACs were also calculated from these model results (see Tables 11 and 12).

Summaries of individual and cumulative MICR for construction activities that would occur in Ventura County and in Los Angeles County are presented in Table 7 and Table 8, respectively. Summaries of individual and cumulative HIC for Ventura County and in Los Angeles County activities are presented in Table 9 and Table 10, respectively. Summaries of individual and cumulative HIA for Ventura County and in Los Angeles County activities are presented in Table 11 and Table 12, respectively.

Cumulative chronic health risks (MICR and HIC) were also calculated to account for the potential impact associated with construction activities that would occur along the same pipeline routes but at different times. These cumulative values were based on the maximum MICR and HIC for each activity regardless of receptor location.

A comparison of maximum cumulative MICR, HIC, and HIA for each individual activity and for cumulative activities is provided below. The predicted MICR and HIC values were estimated to be greater than the health risk criteria of 1×10^{-5} and 1, respectively. The HIA values for pipelay (in both counties) and drilling were estimated to be greater than the health risk criteria of 1.

Location	Activity	MICR	HIC	HIA
Ventura County	Trenching	2.26×10^{-7}	0.01	0.56
	Pipelay	3.25×10^{-7}	0.01	1.02
	Boring	2.90×10^{-6}	0.12	0.57
	ShoreHDB	1.84×10^{-6}	0.08	0.92
	<i>Cumulative - Trenching, Pipelay, Boring</i>	3.45×10^{-6}	0.14	-
	<i>Cumulative - Trenching, Pipelay, Shore HDB</i>	2.39×10^{-6}	0.10	-
Los Angeles County	Trenching	1.11×10^{-7}	0.004	0.45
	Pipelay	2.12×10^{-7}	0.009	1.08
	Drilling	3.56×10^{-6}	0.15	1.19
	<i>Cumulative - Trenching, Pipelay, Drilling</i>	4.01×10^{-6}	0.16	-
Health Risk Criteria		1.00×10^{-5}	1	1

6 DISCUSSION

6.1 Chronic Risks

A health risk analysis was performed to assess potential chronic and acute health risks at locations close to onshore construction activities. The analysis predicts that the maximum exposure to air toxics from construction activities would result in a MICR of 4.01×10^{-6} and a maximum HIC of 0.16. These values are less than the health risk criteria for additional cancer risk of 1×10^{-5} and the chronic non-cancer hazard index criteria of 1. The maximum impacts are predicted to occur right along the boundaries of the modeled pipeline corridor and the drilling/boring area with a steady decrease in impacts away from this boundary.

OEHHA states “Short-term high exposures are not necessarily equivalent to longer-term lower exposures even when the total dose is the same. OEHHA therefore does not support the use of current cancer potency factor to evaluate cancer risk for exposures of less than 9 years. If such risk must be evaluated, we recommend assuming that average daily dose for short-term exposure is assumed to last for a minimum of 9 years” (OEHHA 2003). Given the duration of construction activities at any one location, the approach of assuming 9 years of exposure is expected to greatly overestimate the potential long-term cancer risks to sensitive receptors and the general public.

The length of any of the project construction activities would be considerably less than nine years. Onshore construction activities are not expected to impact any one receptor for more than a few months and for most receptors it would be considerably less time. The construction activities as modeled assume that all construction equipment for a given activity would be operated simultaneously. This is a very conservative assumption as it is highly unlikely that this situation would every take place. Onshore pipeline installation would more likely occur with less equipment at a single location and spread out over much greater distances. Thus, the maximum 1-hour and 24-hour average ambient concentrations predicted during this analysis are deemed to be very conservative in representing potential impacts. For this reason, annual average concentrations for trenching and pipelay were estimated by assuming that receptor locations would be close to all equipment operating simultaneously (as modeled) for 5 days. For drilling and boring, annual average concentrations are based on the assumption that receptors would be

exposed to all equipment operating simultaneously for 30 days. This assumption is also very conservative as each piece of equipment would operate for considerably less time at one specific location. Thus, the approach used for boring and drilling overestimates long-term impacts. For shore crossing HDB, annual average concentrations are based on the assumption that receptors would be exposed to all equipment operating simultaneously for 60 days.

Predicted potential cancer risks associated with chronic exposure to TAC emissions from Project construction activities are less than an additional cancer risk threshold of 1×10^{-5} . Due to the duration of proposed construction activities and related OEHHA guidance on short-term exposure, some degree of uncertainty is associated with the results for long-term cancer risks.

6.2 Acute Risks

The analysis indicates that the exposure to air toxics would result in a maximum acute hazard index (HIA) of approximately 1.2 during pipelay operations and drilling operations. Emissions that cause impacts with a cumulative HIA of 1 or greater have the potential for causing adverse impacts. Thus, the maximum impact is predicted to exceed the health risk criteria by about 20%. For pipelay activities, the maximum impacts occur right along the pipeline corridor with the HIA dropping below 1 at distances of 50 meters (150 feet) away from construction activity. For drilling activities, the maximum impacts are also at the boundary of construction activities with the HIA dropping below 1 at 75 meters (250 feet) away from the construction boundary.

As outlined above, construction activities are modeled under the assumption that all construction equipment would be operated simultaneously. This is a very conservative assumption as it is highly unlikely that this situation would ever take place, especially for pipelay and trenching operations. Onshore pipeline installation would more likely occur with less equipment at a single location and spread out over much greater distances. Thus, the maximum 1-hour ambient concentrations predicted during this analysis are deemed to be very conservative in representing potential impacts.

Approximately 85% of the total HIA is attributed to emissions of acrolein. The acute REL for acrolein of $0.19 \mu\text{g}/\text{m}^3$, which is used to calculate the HIA in this analysis, was developed by OEHHA to be protective of mild adverse effects i.e., eye irritation (OEHHA 1999). The lowest observed adverse effect level (LOAEL) for eye irritation in healthy human volunteers is exposure to $140 \mu\text{g}/\text{m}^3$ (0.06 ppm) acrolein for five minutes. The acute REL was developed from the LOAEL by applying a cumulative uncertainty factor of 60. OEHHA acknowledges there is significant uncertainty in the acute REL for acrolein due to the lack of a no observed adverse effects level (NOAEL) and a short exposure duration in the study for LOAEL (OEHHA 1999).

The acute REL for acrolein developed by OEHHA is significantly lower than acute dose-response values used by various Federal agencies for acrolein. USEPA provided a comparison of acute dose-response values (USEPA 2005). A summary of that comparison for acute exposure levels for acrolein is provided below (in increasing order of value):

OEHHA Acute REL	0.19 µg/m ³	Mild adverse impacts for 1-hour exposures.
ATSDR MRL	6.9 µg/m ³	Minimal risk level for no adverse effects for 1 to 14-day exposure. Draft value (ATSDR 2005).
AEGL-1	69 µg/m ³	Acute exposure guideline level for mild effects for 1-hour exposures. Level is interim.
AEGL-2	230 µg/m ³	Acute exposure guideline level for moderate effects for 1-hour exposures. Level is interim.
ERPG-1	230 µg/m ³	US Department of Energy Emergency Removal Program guidelines for mild and transient effects for 1-hour exposures.
IDLH/10	460 µg/m ³	One-tenth of levels determined by NIOSH to be imminently dangerous to life and health, approximately comparable to mild effects levels for 1-hour exposures.

Key:

ATSDR = Agency for Toxic Substances and Disease Registry (US Dept of Health and Human Services)

If any of these other acute dose-response values were used for acrolein, the cumulative HIA would be less than 0.2 for all construction activities. Due to the limited locations of potential exceedences of HIA, the conservative assumptions used in the dispersion modeling, and the generally conservative nature of the Acute REL for acrolein developed by OEHHA, it is concluded that acute impacts from Project construction activities would not expose the public or sensitive receptors to substantial pollutant concentrations.

7 REFERENCES

California Environmental Protection Agency - Office of Environmental Health Hazard Assessment (OEHHA). 2003. The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments. August.

_____. 1999. Determination of Acute Reference Exposure Levels for Airborne Toxicants: Acute Toxicity Summary – Acrolein. March.

Sierra Research. 2006. California Environmental Quality Act Air Quality Impact Assessment of the BHP Cabrillo Deepwater Port LNG Import Terminal. October 5.

South Coast Air Quality Management District (SCAQMD). 2005. Risk Assessment Procedures for Rules 1401 and 212. Version 7.0. July 1.

United States Department of Health and Human Services - Agency for Toxic Substances and Disease Registry (ATSDR). 2005. ATSDR Minimal Risk Levels. December.

United States Environmental Protection Agency (USEPA). 2004. USEPA Region 9 Preliminary Remediation Goal (PRG) Tables.

_____. Office of Air Quality Planning and Standards. 2005. Acute Dose-Response Values for Screening Risk Assessments. June.

Table 1
Summary of Trenching/Pipelay/Boring Equipment

Activity	Equipment Type	Engine Rating per Device (bhp)	Average Load	Daily Operation (hr/day)	%Hourly Operation	Hourly Fuel Usage ^a (gal/hr)
Trenching	Trenching Machine	1000	80%	12	100%	40.0
	Track Backhoe	500	80%	12	100%	20.0
	Front Loader	200	50%	12	100%	5.0
	Bulldozer	200	50%	12	100%	5.0
	Dragline	200	50%	12	100%	5.0
TOTAL						75.1
Pipelay	Dump Truck	400	50%	4	30%	3.0
	Dump Truck	400	50%	4	30%	3.0
	Water Truck	400	50%	4	30%	3.0
	Water Truck	400	50%	4	30%	3.0
	Utility Truck	400	50%	4	30%	3.0
	Utility Truck	400	50%	4	30%	3.0
	Heavy Fork Lift	200	50%	4	100%	5.0
	Lowboy Truck	400	50%	4	30%	3.0
	Lowboy Truck	400	50%	4	30%	3.0
	Lowboy Truck	400	50%	4	30%	3.0
	Pipe Stringing Truck (mi/day)	400	50%	4	30%	3.0
	Pipe Stringing Truck (mi/day)	400	50%	4	30%	3.0
	Sideboom Tractor	200	50%	12	100%	5.0
	Sideboom Tractor	200	50%	12	100%	5.0
	Mobile Crane	200	50%	12	100%	5.0
	Pipe Bending Machine	100	50%	12	100%	2.5
	Hydrostatic Test Pump	200	50%	12	100%	5.0
	Fill Dirt Screener	200	50%	12	100%	5.0
	Sheepsfoot Compactor	200	50%	12	100%	5.0
	Cement Truck	400	50%	4	30%	3.0
	Cement Truck	400	50%	4	30%	3.0
	Cement Pump	100	50%	12	100%	2.5
	Asphalt Truck	400	50%	4	30%	3.0
	Asphalt Truck	400	50%	4	30%	3.0
	Asphalt Paving Machine	200	50%	12	100%	5.0
	Asphalt Roller	100	50%	12	100%	2.5
TOTAL						95.6
Boring	Horizontal Boring Rig	1000	80%	24	100%	40.0
	Track Backhoe	200	50%	12	100%	5.0
	All Terrain Forklift	100	50%	12	100%	2.5
	Light Towers	20	100%	12	100%	1.0
	Light Towers	20	100%	12	100%	1.0
	Light Towers	20	100%	12	100%	1.0
	Light Towers	20	100%	12	100%	1.0
	Light Towers	20	100%	12	100%	1.0
	Heavy Lift Crane	500	50%	6	100%	12.5
	18 Wheeler Truck	400	50%	4	30%	3.0
TOTAL						72.1

Notes:

a. Based on fuel rate of 6860 Btu/hp-hr

Table 2
Summary of Drilling/ShoreHDB Equipment

Activity	Equipment Type	Engine Rating per Device (bhp)	Average Load	Daily Operation (hr/day)	%Hourly Operation	Hourly Fuel Usage ^a (gal/hr)
Drilling	Large Drilling Rig (HDD)	500	80%	24	100.00%	20.0
	Large Drilling Rig (HDD)	500	80%	24	100.00%	20.0
	Mud Cleaner Generator	400	80%	24	100.00%	16.0
	Mud Pumps	500	80%	24	100.00%	20.0
	Mud Pumps	500	80%	24	100.00%	20.0
	Fluid Handling Pumps	75	80%	24	100.00%	3.0
	Fluid Handling Pumps	75	80%	24	100.00%	3.0
	Fluid Handling Pumps	75	80%	24	100.00%	3.0
	Fluid Handling Pumps	75	80%	24	100.00%	3.0
	Track Backhoe	200	50%	12	100.00%	5.0
	All Terrain Forklift	100	50%	12	100.00%	2.5
	Light Towers	20	100%	12	100.00%	1.0
	Light Towers	20	100%	12	100.00%	1.0
	Light Towers	20	100%	12	100.00%	1.0
	Light Towers	20	100%	12	100.00%	1.0
	Light Towers	20	100%	12	100.00%	1.0
	Light Towers	20	100%	12	100.00%	1.0
	Heavy Lift Crane	500	50%	6	100.00%	12.5
	18 Wheeler Truck (mi/day)	400	50%	4	30%	3.0
	19 Wheeler Truck (mi/day)	400	50%	4	30%	3.0
TOTAL						140.2
ShoreHDB	In-hole head drive unit	400	100%	6	100.00%	20.0
	Mud pumps	400	100%	9	100.00%	20.0
	Mud pumps	400	100%	9	100.00%	20.0
	Solids control unit	500	100%	8	100.00%	25.0
	Thrusting apparatus	300	100%	6	100.00%	15.0
	Electrical generator	400	80%	24	100.00%	16.0
	All Terrain Forklift	100	30%	12	100.00%	1.5
	Mobile crane	400	80%	7.2	100.00%	16.0
	Welding machines	100	80%	12	100.00%	4.0
	Welding machines	100	80%	12	100.00%	4.0
	Welding machines	100	80%	12	100.00%	4.0
	*Contingency	700	100%	24	100.00%	35.0
	18 Wheeler Truck (mi/day)	400	50%	4	30%	3.0
	18 Wheeler Truck (mi/day)	400	50%	4	30%	3.0
TOTAL						186.7

Notes:

a. Based on fuel rate of 6860 Btu/hp-hr

Table 3
Summary of TAC Emission Rates by Construction Activity

Pollutant	Emission Factor ^{a,b} (lb/1000-gal)	PAH Fraction ^c (%)	Hourly Emissions (lb/hr)				
			Trenching	Pipelay	Boring	Drilling	ShoreHDB
Benzene	0.1863	-	0.014	0.0178	0.0134	0.0261	0.0348
Toluene	0.1054	-	0.00791	0.0101	0.00760	0.0148	0.020
Xylenes	0.0424	-	0.00318	0.00405	0.00306	0.00594	0.00792
acenaphthene ^b	0.00062	1.71%	0.00005	0.00006	0.00004	0.00009	0.00012
acenaphthylene ^b	0.00220	6.08%	0.00017	0.00021	0.00016	0.00031	0.00041
anthracene ^b	0.00081	2.25%	0.00006	0.00008	0.00006	0.00011	0.00015
benz(a)anthracene ^b	0.00073	2.02%	0.00005	0.00007	0.00005	0.00010	0.00014
benzo(a)pyrene ^b	0.00008	0.23%	0.00001	0.00001	0.00001	0.00001	0.00002
benzo(b)fluoranthene ^b	0.00004	0.12%	0.00000	0.00000	0.00000	0.00001	0.00001
benzo(g,h,i)perylene ^b	0.00021	0.59%	0.00002	0.00002	0.00002	0.00003	0.00004
benzo(k)fluoranthene ^b	0.00007	0.19%	0.000005	0.000006	0.000005	0.000009	0.000013
chrysene ^b	0.00015	0.42%	0.000012	0.000015	0.000011	0.000022	0.000029
dibenz(a,h)anthracene ^b	0.00025	0.70%	0.000019	0.000024	0.000018	0.000036	0.000047
fluoranthene ^b	0.00331	9.14%	0.000248	0.000316	0.000239	0.000464	0.000618
fluorene ^b	0.01270	35.07%	0.000953	0.001214	0.000915	0.001780	0.002371
indeno(1,2,3-cd)pyrene ^b	0.00016	0.45%	0.000012	0.000016	0.000012	0.000023	0.000030
phenanthrene ^b	0.01278	35.31%	0.000960	0.001222	0.000921	0.001792	0.002387
pyrene ^b	0.00208	5.74%	0.000156	0.000199	0.000150	0.000291	0.000388
Naphthalene	0.0197	-	0.0015	0.00188	0.00142	0.00276	0.0037
Chlorobenzene	0.0002	-	0.000015	0.0000191	0.000014	0.000028	0.0000373
Hexane	0.0269	-	0.00202	0.00257	0.00194	0.00377	0.00502
Ethyl Benzene	0.0109	-	0.000819	0.00104	0.000786	0.00153	0.00204
Hydrogen Chloride	0.1863	-	0.014	0.0178	0.0134	0.0261	0.0348
Arsenic	0.0016	-	0.00012	0.000153	0.000115	0.000224	0.000299
Cadmium	0.0015	-	0.000113	0.000143	0.000108	0.00021	0.000280
Total Chromium	0.0006	-	0.0000451	0.0000574	0.000043	0.0000841	0.000112
Hexavalent Chromium	0.0001	-	0.00000751	0.00000956	0.0000072	0.000014	0.0000187
Copper	0.0041	-	0.000308	0.000392	0.00030	0.000575	0.00077
Lead	0.0083	-	0.000623	0.000794	0.00060	0.00116	0.00155
Manganese	0.0031	-	0.000233	0.000296	0.00022	0.000435	0.000579
Mercury	0.0020	-	0.00015	0.000191	0.00014	0.00028	0.000373
Nickel	0.0039	-	0.000293	0.000373	0.00028	0.000547	0.000728
Selenium	0.0022	-	0.000165	0.00021	0.00016	0.000308	0.00041
Zinc	0.0224	-	0.00168	0.00214	0.0016	0.00314	0.00418
Propylene	0.4670	-	0.0351	0.0447	0.0337	0.0655	0.087
Formaldehyde	1.7261	-	0.13	0.165	0.1244	0.242	0.322
Acetaldehyde	0.7833	-	0.0588	0.0749	0.0565	0.11	0.146
Acrolein	0.0339	-	0.00255	0.00324	0.0024	0.00475	0.00633
1,3-Butadiene	0.2174	-	0.0163	0.0208	0.0157	0.0305	0.041
TOTAL	3.8918	-	0.292	0.372	0.281	0.546	0.727

Notes:

a. Emission factors from [AB 2588 Combustion Emission Factors](#) (VCPACD, May 2001).

b. Emission Factor for each specific PAH = Total PAH (w/o naphthalene) Emission Factor (0.0362 lb/1000-gal) x PAH Fraction.
[Emission factor for Total PAH (w/o naphthalene) from AB 2588 Combustion Emission Factors (VCPACD, May 2001).

c. PAH Fraction based on emission factors of speciated PAHs (w/o naphthalene) in Section 3.3, Table 3.3-2 of [AP-42 Volume 1](#) (EPA 1995)

Table 4
TAC Emissions Rates - Trenching/Pipelay/Boring

Activity	Equipment Type	Hourly Fuel Use Fraction (%)	Total TAC Hourly Emission Rate (lb/hr)	Total TAC Hourly Emission Rate (g/s)	Total TAC Hourly Emission Rate [24-hr Avg] (lb/hr)	Total TAC Hourly Emission Rate [24-hr Avg] (g/s)
Trenching	Trenching Machine	53.3%	0.156	0.0196	0.078	0.00982
	Track Backhoe	26.7%	0.078	0.00982	0.039	0.00491
	Front Loader	6.7%	0.019	0.00245	0.010	0.00123
	Dozer	6.7%	0.019	0.00245	0.010	0.00123
	Dragline	6.7%	0.019	0.00245	0.010	0.00123
Pipelay	TOTAL	100.0%	0.292	0.0368	0.146	0.0184
	Dump Truck	3.1%	0.012	0.00147	0.002	0.000245
	Dump Truck	3.1%	0.012	0.00147	0.002	0.000245
	Water Truck	3.1%	0.012	0.00147	0.002	0.000245
	Water Truck	3.1%	0.012	0.00147	0.002	0.000245
	Utility Truck	3.1%	0.012	0.00147	0.002	0.000245
	Utility Truck	3.1%	0.012	0.00147	0.002	0.000245
	Heavy Fork Lift	5.2%	0.019	0.00245	0.003	0.000409
	Lowboy Truck	3.1%	0.012	0.00147	0.002	0.000245
	Lowboy Truck	3.1%	0.012	0.00147	0.002	0.000245
	Lowboy Truck	3.1%	0.012	0.00147	0.002	0.000245
	Lowboy Truck	3.1%	0.012	0.00147	0.002	0.000245
	Pipe Stringing Truck (mi/day)	3.1%	0.012	0.00147	0.002	0.000245
	Pipe Stringing Truck (mi/day)	3.1%	0.012	0.00147	0.002	0.000245
	Sideboom Tractor	5.2%	0.019	0.00245	0.010	0.00123
	Sideboom Tractor	5.2%	0.019	0.00245	0.010	0.00123
	Mobile Crane	5.2%	0.019	0.00245	0.010	0.00123
	Pipe Bending Machine	2.6%	0.010	0.00123	0.005	0.000614
	Hydrostatic Test Pump	5.2%	0.019	0.00245	0.010	0.00123
	Fill Dirt Screener	5.2%	0.019	0.00245	0.010	0.00123
	Sheepsfoot Compactor	5.2%	0.019	0.00245	0.010	0.00123
	Cement Truck	3.1%	0.012	0.00147	0.002	0.000245
	Cement Truck	3.1%	0.012	0.00147	0.002	0.000245
	Cement Pump	2.6%	0.010	0.00123	0.005	0.000614
Boring	Asphalt Truck	3.1%	0.012	0.00147	0.002	0.000245
	Asphalt Truck	3.1%	0.012	0.00147	0.002	0.000245
	Asphalt Paving Machine	5.2%	0.019	0.00245	0.010	0.00123
	Asphalt Roller	2.6%	0.010	0.00123	0.005	0.000614
	TOTAL	100.0%	0.372	0.0469	0.117	0.0148
	Horizontal Boring Rig	55.6%	0.156	0.01964	0.156	0.0196
	Track Backhoe	6.9%	0.0195	0.00245	0.010	0.00123
	All Terrain Forklift	3.5%	0.0097	0.00123	0.0049	0.000614
	Light Towers	1.4%	0.004	0.000491	0.0019	0.000245
	Light Towers	1.4%	0.004	0.000491	0.0019	0.000245
	Light Towers	1.4%	0.004	0.000491	0.0019	0.000245
	Light Towers	1.4%	0.004	0.000491	0.0019	0.000245
	Light Towers	1.4%	0.004	0.000491	0.0019	0.000245
	Light Towers	1.4%	0.004	0.000491	0.0019	0.000245
	Heavy Lift Crane	17.4%	0.049	0.00614	0.0122	0.00153
	18 Wheeler Truck	4.2%	0.012	0.00147	0.0019	0.000245
	18 Wheeler Truck	4.2%	0.012	0.00147	0.0019	0.000245
	TOTAL	100.0%	0.281	0.0354	0.198	0.0250

Table 5
TAC Emissions Rates - Drilling/ShoreHDB

Activity	Equipment Type	Hourly Fuel Use Fraction (%)	Total TAC Hourly Emission Rate (lb/hr)	Total TAC Hourly Emission Rate (g/s)	Total TAC Hourly Emission Rate [24-hr Avg] (lb/hr)	Total TAC Hourly Emission Rate [24-hr Avg] (g/s)
Drilling	Large Drilling Rig (HDD)	14.3%	0.078	0.00982	0.078	0.00982
	Large Drilling Rig (HDD)	14.3%	0.078	0.00982	0.078	0.00982
	Mud Cleaner Generator	11.4%	0.062	0.00786	0.062	0.00786
	Mud Pumps	14.3%	0.078	0.00982	0.078	0.00982
	Mud Pumps	14.3%	0.078	0.00982	0.078	0.00982
	Fluid Handling Pumps	2.1%	0.012	0.00147	0.012	0.00147
	Fluid Handling Pumps	2.1%	0.012	0.00147	0.012	0.00147
	Fluid Handling Pumps	2.1%	0.012	0.00147	0.012	0.00147
	Fluid Handling Pumps	2.1%	0.012	0.00147	0.012	0.00147
	Track Backhoe	3.6%	0.019	0.00245	0.010	0.00123
	All Terrain Forklift	1.8%	0.010	0.00123	0.005	0.000614
	Light Towers	0.7%	0.004	0.000491	0.002	0.000245
	Light Towers	0.7%	0.004	0.000491	0.002	0.000245
	Light Towers	0.7%	0.004	0.000491	0.002	0.000245
	Light Towers	0.7%	0.004	0.000491	0.002	0.000245
	Light Towers	0.7%	0.004	0.000491	0.002	0.000245
	Heavy Lift Crane	8.9%	0.049	0.00614	0.012	0.00153
	18 Wheeler Truck (mi/day)	2.1%	0.012	0.00147	0.002	0.000245
	19 Wheeler Truck (mi/day)	2.1%	0.012	0.00147	0.002	0.000245
	TOTAL	100.0%	0.546	0.0687	0.463	0.0584
ShoreHDB	In-hole head drive unit	10.7%	0.078	0.00982	0.019	0.00245
	Mud pumps	10.7%	0.078	0.00982	0.029	0.00368
	Mud pumps	10.7%	0.078	0.00982	0.029	0.00368
	Solids control unit	13.4%	0.097	0.0123	0.032	0.00409
	Thrusting apparatus	8.0%	0.058	0.00736	0.015	0.00184
	Electrical generator	8.6%	0.062	0.00786	0.062	0.00786
	All Terrain Forklift	0.8%	0.006	0.000736	0.003	0.000368
	Mobile crane	8.6%	0.062	0.00786	0.019	0.00236
	Welding machines	2.1%	0.016	0.00196	0.008	0.000982
	Welding machines	2.1%	0.016	0.00196	0.008	0.000982
	Welding machines	2.1%	0.016	0.00196	0.008	0.000982
	*Contingency	18.8%	0.136	0.0172	0.136	0.0172
	18 Wheeler Truck (mi/day)	1.6%	0.012	0.00147	0.002	0.000245
	19 Wheeler Truck (mi/day)	1.6%	0.012	0.00147	0.002	0.000245
	TOTAL	100.0%	0.727	0.0916	0.373	0.0470

Table 6
Summary of Modeled Impacts and Risk Analysis Parameters

Parameter		Units	Ventura County				Los Angeles County		
			Trenching	Pipelay	Boring	Shore HDB	Trenching	Pipelay	Drilling
Total TAC Impact	PeakConc (1-hr)	µg/m ³	10.5	19.2	10.8	17.2	8.4	20.2	22.3
	24-hr AvgConc	µg/m ³	2.33	3.5	2.8	2.81	1.2	2.0	8.3
	5-day AvgConc	µg/m ³	1.94	2.9	-	-	0.96	1.8	-
	Monthly AvgConc	µg/m ³	-	-	1.4	1.36	-	-	3.7
	AveConc (Annual) ^a	µg/m ³	0.027	0.040	0.12	0.11	0.013	0.025	0.30
Total DPM Impact	PeakConc (1-hr)	µg/m ³	-	-	-	-	-	-	-
	24-hr AvgConc	µg/m ³	4.0	6.0	10.9	4.81	2.1	3.4	21.2
	5-day AvgConc	µg/m ³	3.3	4.8	-	-	1.6	3.1	-
	Monthly AvgConc	µg/m ³	-	-	7.3	2.3	-	-	8.8
	AveConc (Annual) ^a	µg/m ³	0.045	0.065	0.60	0.38	0.022	0.042	0.72
Days of Operation	days	5	5	30	60	5	5	5	30
EVF ^b	-	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143
AF _{ann}	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
DBR		302	302	302	302	302	302	302	302

Notes:

a. For trenching and pipelay, AveConc = 5-day AvgConc x (5 days / 365 days)

For boring and drilling, AveConc = 30-day average x (30 days / 365 days)

For Shore HDB, AveConc = 30-day average x (60 days / 365 days)

b. EVF = 1 year (365 days) / 70 years (25550 days)

Table 7
Summary of Maximum Cancer Risks - Ventura County

Pollutant	Cancer CP (mg/kg-day) ⁻¹	MP _R [Cancer]	AveConc ($\mu\text{g}/\text{m}^3$)				MICR			
			Trenching	Pipelay	Boring	ShoreHDB	Trenching	Pipelay	Boring	ShoreHDB
Benzene	0.1	1.00	1.27E-03	1.90E-03	5.63E-03	5.35E-03	5.49E-10	8.20E-10	2.43E-09	2.31E-09
Toluene			7.20E-04	1.08E-03	3.18E-03	3.03E-03				
Xylenes			2.90E-04	4.33E-04	1.28E-03	1.22E-03				
acenaphthene			4.22E-06	6.30E-06	1.86E-05	1.77E-05				
acenaphthylene			1.50E-05	2.25E-05	6.64E-05	6.32E-05				
anthracene			5.55E-06	8.30E-06	2.46E-05	2.34E-05				
benz(a)anthracene	0.39	29.76	4.99E-06	7.46E-06	2.21E-05	2.10E-05	2.50E-10	3.73E-10	1.10E-09	1.05E-09
benzo(a)pyrene	3.9	29.76	5.58E-07	8.34E-07	2.47E-06	2.35E-06	2.79E-10	4.18E-10	1.24E-09	1.18E-09
benzo(b)fluoranthene	0.39	29.76	2.94E-07	4.40E-07	1.30E-06	1.24E-06	1.47E-11	2.20E-11	6.52E-11	6.20E-11
benzo(g,h,i)perylene			1.45E-06	2.17E-06	6.42E-06	6.11E-06				
benzo(k)fluoranthene	0.39	29.76	4.60E-07	6.88E-07	2.04E-06	1.94E-06	2.30E-11	3.44E-11	1.02E-10	9.69E-11
chrysene	0.039	29.76	1.05E-06	1.57E-06	4.64E-06	4.41E-06	5.25E-12	7.84E-12	2.32E-11	2.21E-11
dibenz(a,h)anthracene	4.1	10.26	1.73E-06	2.59E-06	7.65E-06	7.28E-06	3.14E-10	4.70E-10	1.39E-09	1.32E-09
fluoranthene			2.26E-05	3.38E-05	9.99E-05	9.50E-05				
fluorene			8.67E-05	1.30E-04	3.83E-04	3.65E-04				
indeno(1,2,3-cd)pyrene	0.39	29.76	1.11E-06	1.66E-06	4.92E-06	4.68E-06	5.57E-11	8.33E-11	2.47E-10	2.34E-10
phenanthrene			8.73E-05	1.30E-04	3.86E-04	3.67E-04				
pyrene			1.42E-05	2.12E-05	6.28E-05	5.97E-05				
Naphthalene	0.12	1.00	1.35E-04	2.01E-04	5.95E-04	5.66E-04	6.96E-11	1.04E-10	3.08E-10	2.93E-10
Chlorobenzene			1.37E-06	2.04E-06	6.04E-06	5.74E-06				
Hexane			1.84E-04	2.75E-04	8.12E-04	7.73E-04				
Ethyl Benzene			7.44E-05	1.11E-04	3.29E-04	3.13E-04				
Hydrogen Chloride			1.27E-03	1.90E-03	5.63E-03	5.35E-03				
Arsenic	12	4.78	1.09E-05	1.63E-05	4.83E-05	4.60E-05	2.70E-09	4.04E-09	1.20E-08	1.14E-08
Cadmium	15	1.00	1.02E-05	1.53E-05	4.53E-05	4.31E-05	6.63E-10	9.91E-10	2.93E-09	2.79E-09
Total Chromium			4.10E-06	6.12E-06	1.81E-05	1.72E-05				
Hexavalent Chromium	510	1.00	6.83E-07	1.02E-06	3.02E-06	2.87E-06	1.50E-09	2.25E-09	6.64E-09	6.32E-09
Copper			2.80E-05	4.19E-05	1.24E-04	1.18E-04				
Lead	0.042	4.19	5.67E-05	8.47E-05	2.51E-04	2.38E-04	4.30E-11	6.43E-11	1.90E-10	1.81E-10
Manganese			2.12E-05	3.16E-05	9.36E-05	8.90E-05				
Mercury			1.37E-05	2.04E-05	6.04E-05	5.74E-05				
Nickel	0.91	1.00	2.66E-05	3.98E-05	1.18E-04	1.12E-04	1.05E-10	1.56E-10	4.62E-10	4.40E-10
Selenium			1.50E-05	2.25E-05	6.64E-05	6.32E-05				
Zinc			1.53E-04	2.29E-04	6.76E-04	6.43E-04				
Propylene			3.19E-03	4.77E-03	1.41E-02	1.34E-02				
Formaldehyde	0.021	1.00	1.18E-02	1.76E-02	5.21E-02	4.96E-02	1.07E-09	1.60E-09	4.72E-09	4.49E-09
Acetaldehyde	0.01	1.00	5.35E-03	8.00E-03	2.37E-02	2.25E-02	2.31E-10	3.45E-10	1.02E-09	9.71E-10
Acrolein			2.31E-04	3.46E-04	1.02E-03	9.74E-04				
1,3-Butadiene	0.6	1.00	1.48E-03	2.22E-03	6.57E-03	6.24E-03	3.84E-09	5.74E-09	1.70E-08	1.62E-08
Subtotal	-	-	0.027	0.040	0.12	0.11	1.12E-08	1.67E-08	4.94E-08	4.70E-08
Diesel PM	1.1	1.00	0.045	0.065	0.60	0.38	2.15E-07	3.09E-07	2.85E-06	1.79E-06
TOTAL							2.26E-07	3.25E-07	2.90E-06	1.84E-06

Table 8
Summary of Maximum Cancer Risks - Los Angeles County

Pollutant	Cancer CP (mg/kg-day) ⁻¹	MP _R [Cancer]	AveConc ($\mu\text{g}/\text{m}^3$)			MICR		
			Trenching	Pipelay	Drilling	Trenching	Pipelay	Drilling
Benzene	0.1	1.00	6.30E-04	1.18E-03	1.46E-02	2.72E-10	5.09E-10	6.28E-09
Toluene			3.56E-04	6.68E-04	8.24E-03			
Xylenes			1.43E-04	2.69E-04	3.31E-03			
acenaphthene			2.09E-06	3.91E-06	4.82E-05			
acenaphthylene			7.43E-06	1.39E-05	1.72E-04			
anthracene			2.75E-06	5.15E-06	6.35E-05			
benz(a)anthracene	0.39	29.76	2.47E-06	4.63E-06	5.71E-05	1.24E-10	2.32E-10	2.86E-09
benzo(a)pyrene	3.9	29.76	2.76E-07	5.18E-07	6.39E-06	1.38E-10	2.59E-10	3.20E-09
benzo(b)fluoranthene	0.39	29.76	1.46E-07	2.73E-07	3.37E-06	7.29E-12	1.37E-11	1.69E-10
benzo(g,h,i)perylene			7.18E-07	1.35E-06	1.66E-05			
benzo(k)fluoranthene	0.39	29.76	2.28E-07	4.27E-07	5.27E-06	1.14E-11	2.14E-11	2.64E-10
chrysene	0.039	29.76	5.19E-07	9.72E-07	1.20E-05	2.60E-12	4.87E-12	6.01E-11
dibenz(a,h)anthracene	4.1	10.26	8.57E-07	1.61E-06	1.98E-05	1.55E-10	2.91E-10	3.59E-09
fluoranthene			1.12E-05	2.10E-05	2.59E-04			
fluorene			4.29E-05	8.04E-05	9.92E-04			
indeno(1,2,3-cd)pyrene	0.39	29.76	5.51E-07	1.03E-06	1.27E-05	2.76E-11	5.17E-11	6.38E-10
phenanthrene			4.32E-05	8.10E-05	9.99E-04			
pyrene			7.02E-06	1.32E-05	1.62E-04			
Naphthalene	0.12	1.00	6.66E-05	1.25E-04	1.54E-03	3.45E-11	6.46E-11	7.97E-10
Chlorobenzene			6.76E-07	1.27E-06	1.56E-05			
Hexane			9.09E-05	1.70E-04	2.10E-03			
Ethyl Benzene			3.68E-05	6.91E-05	8.52E-04			
Hydrogen Chloride			6.30E-04	1.18E-03	1.46E-02			
Arsenic	12	4.78	5.41E-06	1.01E-05	1.25E-04	1.34E-09	2.51E-09	3.09E-08
Cadmium	15	1.00	5.07E-06	9.50E-06	1.17E-04	3.28E-10	6.15E-10	7.59E-09
Total Chromium			2.03E-06	3.80E-06	4.69E-05			
Hexavalent Chromium	510	1.00	3.38E-07	6.34E-07	7.81E-06	7.43E-10	1.39E-09	1.72E-08
Copper			1.39E-05	2.60E-05	3.20E-04			
Lead	0.042	4.19	2.80E-05	5.26E-05	6.49E-04	2.13E-11	3.99E-11	4.92E-10
Manganese			1.05E-05	1.96E-05	2.42E-04			
Mercury			6.76E-06	1.27E-05	1.56E-04			
Nickel	0.91	1.00	1.32E-05	2.47E-05	3.05E-04	5.17E-11	9.70E-11	1.20E-09
Selenium			7.43E-06	1.39E-05	1.72E-04			
Zinc			7.57E-05	1.42E-04	1.75E-03			
Propylene			1.58E-03	2.96E-03	3.65E-02			
Formaldehyde	0.021	1.00	5.83E-03	1.09E-02	1.35E-01	5.28E-10	9.91E-10	1.22E-08
Acetaldehyde	0.01	1.00	2.65E-03	4.96E-03	6.12E-02	1.14E-10	2.14E-10	2.64E-09
Acrolein			1.15E-04	2.15E-04	2.65E-03			
1,3-Butadiene	0.6	1.00	7.35E-04	1.38E-03	1.70E-02	1.90E-09	3.57E-09	4.40E-08
Subtotal	-	-	0.013	0.025	0.30	5.53E-09	1.04E-08	1.28E-07
Diesel PM	1.1	1.00	0.022	0.042	0.72	1.04E-07	2.02E-07	3.43E-06
TOTAL					-	1.10E-07	2.12E-07	3.56E-06

Table 9
Summary of Maximum Non-Cancer Chronic Risks - Ventura County

Pollutant	Chronic REL ^a ($\mu\text{g}/\text{m}^3$)	MP _R	AveConc ($\mu\text{g}/\text{m}^3$)				Total HIC			
			Trenching	Pipelay	Boring	ShoreHDB	Trenching	Pipelay	Boring	ShoreHDB
Benzene	60	1.00	1.27E-03	1.90E-03	5.63E-03	5.35E-03	2.12E-05	3.17E-05	9.38E-05	8.92E-05
Toluene	300	1.00	7.20E-04	1.08E-03	3.18E-03	3.03E-03	2.40E-06	3.59E-06	1.06E-05	1.01E-05
Xylenes	700	1.00	2.90E-04	4.33E-04	1.28E-03	1.22E-03	4.14E-07	6.18E-07	1.83E-06	1.74E-06
acenaphthene	210	1.00	4.22E-06	6.30E-06	1.86E-05	1.77E-05	2.01E-08	3.00E-08	8.88E-08	8.44E-08
acenaphthylene	210	1.00	1.50E-05	2.25E-05	6.64E-05	6.32E-05	7.15E-08	1.07E-07	3.16E-07	3.01E-07
anthracene	1050	1.00	5.55E-06	8.30E-06	2.46E-05	2.34E-05	5.29E-09	7.90E-09	2.34E-08	2.22E-08
benz(a)anthracene			4.99E-06	7.46E-06	2.21E-05	2.10E-05				
benzo(a)pyrene			5.58E-07	8.34E-07	2.47E-06	2.35E-06				
benzo(b)fluoranthene			2.94E-07	4.40E-07	1.30E-06	1.24E-06				
benzo(g,h,i)perylene	105	1.00	1.45E-06	2.17E-06	6.42E-06	6.11E-06	1.38E-08	2.07E-08	6.11E-08	5.82E-08
benzo(k)fluoranthene			4.60E-07	6.88E-07	2.04E-06	1.94E-06				
chrysene			1.05E-06	1.57E-06	4.64E-06	4.41E-06				
dibenz(a,h)anthracene			1.73E-06	2.59E-06	7.65E-06	7.28E-06				
fluoranthene	140	1.00	2.26E-05	3.38E-05	9.99E-05	9.50E-05	1.61E-07	2.41E-07	7.14E-07	6.79E-07
fluorene	140	1.00	8.67E-05	1.30E-04	3.83E-04	3.65E-04	6.19E-07	9.26E-07	2.74E-06	2.60E-06
indeno(1,2,3-cd)pyrene			1.11E-06	1.66E-06	4.92E-06	4.68E-06				
phenanthrene	1050	1.00	8.73E-05	1.30E-04	3.86E-04	3.67E-04	8.31E-08	1.24E-07	3.68E-07	3.50E-07
pyrene	105	1.00	1.42E-05	2.12E-05	6.28E-05	5.97E-05	1.35E-07	2.02E-07	5.98E-07	5.68E-07
Naphthalene	9	1.00	1.35E-04	2.01E-04	5.95E-04	5.66E-04	1.49E-05	2.23E-05	6.61E-05	6.29E-05
Chlorobenzene	1000	1.00	1.37E-06	2.04E-06	6.04E-06	5.74E-06	1.37E-09	2.04E-09	6.04E-09	5.74E-09
Hexane	7000	1.00	1.84E-04	2.75E-04	8.12E-04	7.73E-04	2.62E-08	3.92E-08	1.16E-07	1.10E-07
Ethyl Benzene	2000	1.00	7.44E-05	1.11E-04	3.29E-04	3.13E-04	3.72E-08	5.56E-08	1.65E-07	1.57E-07
Hydrogen Chloride	9	1.00	1.27E-03	1.90E-03	5.63E-03	5.35E-03	1.41E-04	2.11E-04	6.25E-04	5.95E-04
Arsenic	0.03	1.91	1.09E-05	1.63E-05	4.83E-05	4.60E-05	6.96E-04	1.04E-03	3.08E-03	2.93E-03
Cadmium	0.02	1.50	1.02E-05	1.53E-05	4.53E-05	4.31E-05	7.68E-04	1.15E-03	3.40E-03	3.23E-03
Total Chromium			4.10E-06	6.12E-06	1.81E-05	1.72E-05				
Hexavalent Chromium	0.2	1.00	6.83E-07	1.02E-06	3.02E-06	2.87E-06	3.41E-06	5.10E-06	1.51E-05	1.44E-05
Copper			2.80E-05	4.19E-05	1.24E-04	1.18E-04				
Lead			5.67E-05	8.47E-05	2.51E-04	2.38E-04				
Manganese	0.2	1.00	2.12E-05	3.16E-05	9.36E-05	8.90E-05	1.06E-04	1.58E-04	4.68E-04	4.45E-04
Mercury	0.09	10.06	1.37E-05	2.04E-05	6.04E-05	5.74E-05	1.53E-03	2.28E-03	6.75E-03	6.42E-03
Nickel	0.05	1.00	2.66E-05	3.98E-05	1.18E-04	1.12E-04	5.33E-04	7.96E-04	2.36E-03	2.24E-03
Selenium	20	1.00	1.50E-05	2.25E-05	6.64E-05	6.32E-05	7.51E-07	1.12E-06	3.32E-06	3.16E-06
Zinc			1.53E-04	2.29E-04	6.76E-04	6.43E-04				
Propylene	3000	1.00	3.19E-03	4.77E-03	1.41E-02	1.34E-02	1.06E-06	1.59E-06	4.70E-06	4.47E-06
Formaldehyde	3	1.00	1.18E-02	1.76E-02	5.21E-02	4.96E-02	3.93E-03	5.87E-03	1.74E-02	1.65E-02
Acetaldehyde	9	1.00	5.35E-03	8.00E-03	2.37E-02	2.25E-02	5.94E-04	8.88E-04	2.63E-03	2.50E-03
Acrolein	0.06	1.00	2.31E-04	3.46E-04	1.02E-03	9.74E-04	3.86E-03	5.77E-03	1.71E-02	1.62E-02
1,3-Butadiene	20	1.00	1.48E-03	2.22E-03	6.57E-03	6.24E-03	7.42E-05	1.11E-04	3.28E-04	3.12E-04
Subtotal	-	-	0.027	0.040	0.12	0.11	0.00004	0.00006	0.00018	0.00017
Diesel PM	5	1.00	0.045	0.065	0.60	0.38	0.01	0.01	0.12	0.08
TOTAL							0.01	0.01	0.12	0.08

Notes:

a. Chronic REL from OEHHA TCDB except as noted below:

Acenaphthene, anthracene, fluoranthene, fluorene, and pyrene from Region 9 PRG Table (EPA 2004).

Acenaphthylene based on data for acenaphthene; benzo(g,h,i)perylene based on data for pyrene;

phenanthrene: based on data for anthracene.

Table 10
Summary of Maximum Non-Cancer Chronic Risk - Los Angeles County

Pollutant	Chronic REL ^a ($\mu\text{g}/\text{m}^3$)	MP _R	AveConc ($\mu\text{g}/\text{m}^3$)			Total HIC		
			Trenching	Pipelay	Drilling	Trenching	Pipelay	Drilling
Benzene	60	1.00	6.30E-04	1.18E-03	1.46E-02	1.05E-05	1.97E-05	2.43E-04
Toluene	300	1.00	3.56E-04	6.68E-04	8.24E-03	1.19E-06	2.23E-06	2.75E-05
Xylenes	700	1.00	1.43E-04	2.69E-04	3.31E-03	2.05E-07	3.84E-07	4.73E-06
acenaphthene	210	1.00	2.09E-06	3.91E-06	4.82E-05	9.93E-09	1.86E-08	2.30E-07
acenaphthylene	210	1.00	7.43E-06	1.39E-05	1.72E-04	3.54E-08	6.64E-08	8.19E-07
anthracene	1050	1.00	2.75E-06	5.15E-06	6.35E-05	2.62E-09	4.91E-09	6.05E-08
benz(a)anthracene			2.47E-06	4.63E-06	5.71E-05			
benzo(a)pyrene			2.76E-07	5.18E-07	6.39E-06			
benzo(b)fluoranthene			1.46E-07	2.73E-07	3.37E-06			
benzo(g,h,i)perylene	105	1.00	7.18E-07	1.35E-06	1.66E-05	6.84E-09	1.28E-08	1.58E-07
benzo(k)fluoranthene			2.28E-07	4.27E-07	5.27E-06			
chrysene			5.19E-07	9.72E-07	1.20E-05			
dibenz(a,h)anthracene			8.57E-07	1.61E-06	1.98E-05			
fluoranthene	140	1.00	1.12E-05	2.10E-05	2.59E-04	7.99E-08	1.50E-07	1.85E-06
fluorene	140	1.00	4.29E-05	8.04E-05	9.92E-04	3.06E-07	5.75E-07	7.09E-06
indeno(1,2,3-cd)pyrene			5.51E-07	1.03E-06	1.27E-05			
phenanthrene	1050	1.00	4.32E-05	8.10E-05	9.99E-04	4.11E-08	7.71E-08	9.51E-07
pyrene	105	1.00	7.02E-06	1.32E-05	1.62E-04	6.69E-08	1.25E-07	1.55E-06
Naphthalene	9	1.00	6.66E-05	1.25E-04	1.54E-03	7.40E-06	1.39E-05	1.71E-04
Chlorobenzene	1000	1.00	6.76E-07	1.27E-06	1.56E-05	6.76E-10	1.27E-09	1.56E-08
Hexane	7000	1.00	9.09E-05	1.70E-04	2.10E-03	1.30E-08	2.43E-08	3.00E-07
Ethyl Benzene	2000	1.00	3.68E-05	6.91E-05	8.52E-04	1.84E-08	3.45E-08	4.26E-07
Hydrogen Chloride	9	1.00	6.30E-04	1.18E-03	1.46E-02	6.99E-05	1.31E-04	1.62E-03
Arsenic	0.03	1.91	5.41E-06	1.01E-05	1.25E-04	3.44E-04	6.45E-04	7.96E-03
Cadmium	0.02	1.50	5.07E-06	9.50E-06	1.17E-04	3.80E-04	7.13E-04	8.79E-03
Total Chromium			2.03E-06	3.80E-06	4.69E-05			
Hexavalent Chromium	0.2	1.00	3.38E-07	6.34E-07	7.81E-06	1.69E-06	3.17E-06	3.91E-05
Copper			1.39E-05	2.60E-05	3.20E-04			
Lead			2.80E-05	5.26E-05	6.49E-04			
Manganese	0.2	1.00	1.05E-05	1.96E-05	2.42E-04	5.24E-05	9.82E-05	1.21E-03
Mercury	0.09	10.06	6.76E-06	1.27E-05	1.56E-04	7.55E-04	1.42E-03	1.75E-02
Nickel	0.05	1.00	1.32E-05	2.47E-05	3.05E-04	2.64E-04	4.94E-04	6.10E-03
Selenium	20	1.00	7.43E-06	1.39E-05	1.72E-04	3.72E-07	6.97E-07	8.60E-06
Zinc			7.57E-05	1.42E-04	1.75E-03			
Propylene	3000	1.00	1.58E-03	2.96E-03	3.65E-02	5.26E-07	9.86E-07	1.22E-05
Formaldehyde	3	1.00	5.83E-03	1.09E-02	1.35E-01	1.94E-03	3.65E-03	4.50E-02
Acetaldehyde	9	1.00	2.65E-03	4.96E-03	6.12E-02	2.94E-04	5.51E-04	6.80E-03
Acrolein	0.06	1.00	1.15E-04	2.15E-04	2.65E-03	1.91E-03	3.58E-03	4.41E-02
1,3-Butadiene	20	1.00	7.35E-04	1.38E-03	1.70E-02	3.67E-05	6.89E-05	8.49E-04
<i>Subtotal</i>	-	-	0.013	0.025	0.30	0.00002	0.00004	0.00046
Diesel PM	5	1.00	0.022	0.042	0.72	0.004	0.008	0.14
TOTAL					-	0.004	0.009	0.15

Notes:

a. Chronic REL from OEHHA TCDB except as noted below:

Acenaphthene, anthracene, fluoranthene, fluorene, and pyrene from Region 9 PRG Table (EPA 2004).

Acenaphthylene based on data for acenaphthene; benzo(g,h,i)perylene based on data for pyrene;

phenanthrene: based on data for anthracene.

Table 11
Summary of Maximum Acute Risks - Ventura County

Pollutant	Acute REL ^a ($\mu\text{g}/\text{m}^3$)	PeakConc ($\mu\text{g}/\text{m}^3$)				Total HIA			
		Trenching	Pipelay	Boring	ShoreHDB	Trenching	Pipelay	Boring	ShoreHDB
Benzene	1300	5.01E-01	9.19E-01	5.15E-01	8.23E-01	0.00039	0.00071	0.00040	0.00063
Toluene	37000	2.84E-01	5.20E-01	2.91E-01	4.66E-01	0.0000077	0.0000141	0.0000079	0.0000126
Xylenes	22000	1.14E-01	2.09E-01	1.17E-01	1.87E-01	0.0000052	0.0000095	0.0000053	0.0000085
acenaphthene		1.66E-03	3.05E-03	1.71E-03	2.73E-03				
acenaphthylene		5.92E-03	1.09E-02	6.08E-03	9.72E-03				
anthracene		2.19E-03	4.01E-03	2.25E-03	3.59E-03				
benz(a)anthracene		1.97E-03	3.60E-03	2.02E-03	3.23E-03				
benzo(a)pyrene		2.20E-04	4.03E-04	2.26E-04	3.61E-04				
benzo(b)fluoranthene		1.16E-04	2.13E-04	1.19E-04	1.90E-04				
benzo(g,h,i)perylene		5.72E-04	1.05E-03	5.87E-04	9.40E-04				
benzo(k)fluoranthene		1.81E-04	3.32E-04	1.86E-04	2.98E-04				
chrysene		4.13E-04	7.57E-04	4.24E-04	6.78E-04				
dibenz(a,h)anthracene		6.82E-04	1.25E-03	7.00E-04	1.12E-03				
fluoranthene		8.90E-03	1.63E-02	9.14E-03	1.46E-02				
fluorene		3.42E-02	6.26E-02	3.51E-02	5.61E-02				
indeno(1,2,3-cd)pyrene		4.39E-04	8.04E-04	4.50E-04	7.21E-04				
phenanthrene		3.44E-02	6.31E-02	3.53E-02	5.65E-02				
pyrene		5.59E-03	1.03E-02	5.74E-03	9.18E-03				
Naphthalene		5.30E-02	9.72E-02	5.44E-02	8.71E-02				
Chlorobenzene		5.38E-04	9.87E-04	5.52E-04	8.84E-04				
Hexane		7.24E-02	1.33E-01	7.43E-02	1.19E-01				
Ethyl Benzene		2.93E-02	5.38E-02	3.01E-02	4.82E-02				
Hydrogen Chloride	2100	5.01E-01	9.19E-01	5.15E-01	8.23E-01	0.00024	0.00044	0.00025	0.00039
Arsenic	0.19	4.30E-03	7.89E-03	4.42E-03	7.07E-03	0.023	0.042	0.023	0.037
Cadmium		4.04E-03	7.40E-03	4.14E-03	6.63E-03				
Total Chromium		1.61E-03	2.96E-03	1.66E-03	2.65E-03				
Hexavalent Chromium		2.69E-04	4.93E-04	2.76E-04	4.42E-04				
Copper	100	1.10E-02	2.02E-02	1.13E-02	1.81E-02	0.000110	0.000202	0.000113	0.000181
Lead		2.23E-02	4.09E-02	2.29E-02	3.67E-02				
Manganese		8.34E-03	1.53E-02	8.56E-03	1.37E-02				
Mercury	1.8	5.38E-03	9.87E-03	5.52E-03	8.84E-03	0.0030	0.0055	0.0031	0.0049
Nickel	6	1.05E-02	1.92E-02	1.08E-02	1.72E-02	0.0017	0.0032	0.0018	0.0029
Selenium		5.92E-03	1.09E-02	6.08E-03	9.72E-03				
Zinc		6.03E-02	1.11E-01	6.19E-02	9.90E-02				
Propylene		1.26E+00	2.30E+00	1.29E+00	2.06E+00				
Formaldehyde	94	4.64E+00	8.52E+00	4.77E+00	7.63E+00	0.049	0.091	0.051	0.081
Acetaldehyde		2.11E+00	3.86E+00	2.16E+00	3.46E+00				
Acrolein	0.19	9.12E-02	1.67E-01	9.36E-02	1.50E-01	0.48	0.88	0.49	0.79
1,3-Butadiene		5.85E-01	1.07E+00	6.01E-01	9.61E-01				
TOTAL		10.5	19.2	10.8	17.2	0.56	1.02	0.57	0.92

Table 12
Summary of Maximum Acute Risks - Los Angeles County

Pollutant	Acute REL ^a ($\mu\text{g}/\text{m}^3$)	PeakConc ($\mu\text{g}/\text{m}^3$)			Total HIA		
		Trenching	Pipelay	Drilling	Trenching	Pipelay	Drilling
Benzene	1300	4.01E-01	9.67E-01	1.07E+00	0.00031	0.00074	0.00082
Toluene	37000	2.27E-01	5.47E-01	6.04E-01	0.0000061	0.0000148	0.0000163
Xylenes	22000	9.12E-02	2.20E-01	2.43E-01	0.0000041	0.0000100	0.0000110
acenaphthene		1.33E-03	3.20E-03	3.54E-03			
acenaphthylene		4.73E-03	1.14E-02	1.26E-02			
anthracene		1.75E-03	4.22E-03	4.66E-03			
benz(a)anthracene		1.57E-03	3.79E-03	4.19E-03			
benzo(a)pyrene		1.76E-04	4.24E-04	4.68E-04			
benzo(b)fluoranthene		9.27E-05	2.24E-04	2.47E-04			
benzo(g,h,i)perylene		4.57E-04	1.10E-03	1.22E-03			
benzo(k)fluoranthene		1.45E-04	3.50E-04	3.86E-04			
chrysene		3.30E-04	7.97E-04	8.79E-04			
dibenz(a,h)anthracene		5.45E-04	1.32E-03	1.45E-03			
fluoranthene		7.12E-03	1.72E-02	1.90E-02			
fluorene		2.73E-02	6.59E-02	7.27E-02			
indeno(1,2,3-cd)pyrene		3.51E-04	8.46E-04	9.34E-04			
phenanthrene		2.75E-02	6.63E-02	7.32E-02			
pyrene		4.47E-03	1.08E-02	1.19E-02			
Naphthalene		4.24E-02	1.02E-01	1.13E-01			
Chlorobenzene		4.30E-04	1.04E-03	1.15E-03			
Hexane		5.79E-02	1.40E-01	1.54E-01			
Ethyl Benzene		2.34E-02	5.66E-02	6.25E-02			
Hydrogen Chloride	2100	4.01E-01	9.67E-01	1.07E+00	0.00019	0.00046	0.00051
Arsenic	0.19	3.44E-03	8.30E-03	9.17E-03	0.018	0.044	0.048
Cadmium		3.23E-03	7.79E-03	8.59E-03			
Total Chromium		1.29E-03	3.11E-03	3.44E-03			
Hexavalent Chromium		2.15E-04	5.19E-04	5.73E-04			
Copper	100	8.82E-03	2.13E-02	2.35E-02	0.000088	0.000213	0.000235
Lead		1.79E-02	4.31E-02	4.76E-02			
Manganese		6.67E-03	1.61E-02	1.78E-02			
Mercury	1.8	4.30E-03	1.04E-02	1.15E-02	0.0024	0.0058	0.0064
Nickel	6	8.39E-03	2.02E-02	2.23E-02	0.0014	0.0034	0.0037
Selenium		4.73E-03	1.14E-02	1.26E-02			
Zinc		4.82E-02	1.16E-01	1.28E-01			
Propylene		1.00E+00	2.42E+00	2.68E+00			
Formaldehyde	94	3.71E+00	8.96E+00	9.89E+00	0.039	0.095	0.105
Acetaldehyde		1.68E+00	4.07E+00	4.49E+00			
Acrolein	0.19	7.29E-02	1.76E-01	1.94E-01	0.38	0.93	1.02
1,3-Butadiene		4.68E-01	1.13E+00	1.25E+00			
TOTAL		8.4	20.2	22.3	0.45	1.08	1.19

Appendix G6-2

Health Risk Analysis

Toxic Air Contaminant Emissions from Operational Activities

Cabrillo Port LNG Deepwater Port Project

1 INTRODUCTION

1.1 Objective

The objective of this health risk analysis was to evaluate cancer risk and non-cancer acute and chronic hazard indices due to toxic air contaminants (TAC) emissions during operation of the Cabrillo Port Liquefied Natural Gas Deepwater Port (the Project). Cancer risk and acute and chronic hazard indices were estimated for onshore locations in proximity to Project activities. The analysis included FSRU equipment (e.g., main generators and submerged combustion vaporizers [SCVs]), LNG carriers and support vessels (i.e., tugs and crew boat).

2 METHODOLOGY

In the revised health risk analysis, potential ambient TAC concentrations at onshore locations due to Project operational emissions were predicted with the Offshore Coastal and Dispersion Model (OCD). This model was developed by the Minerals Management Service (MMS) and is approved for overwater emission sources by the United States Environmental Protection Agency (USEPA). These predicted ambient TAC concentrations were then used to estimate long-term (chronic) and short-term (acute) health risks associated with Project operations.

3 DISPERSION MODEL INPUTS

3.1 Emission Sources

FSRU equipment and Project vessels were categorized into three different source types as follows:

- Natural gas-fueled internal combustion sources
 - Main FSRU generators
 - LNG carrier engines
- Natural gas-fueled external combustion sources
 - Submerged combustion vaporizers (SCVs)
- Diesel-fueled internal combustion sources
 - Main FSRU generators
 - Normal operation (diesel as pilot fuel)
 - Backup operation (diesel as primary fuel)
 - FSRU auxiliary and/or emergency equipment
 - Supply tug engines
 - Crewboat engines
 - LNG carrier engines (diesel as pilot fuel)

LNG carrier and support vessels were further segmented by operational location (i.e., district waters, Federal waters, safety zone). The prediction of annual average TAC ambient concentrations, used for estimation of chronic impacts, accounted for annual average operation of all equipment and vessels. The prediction of maximum 1-hour TAC ambient concentrations, used for estimation of acute impacts, was based on FSRU and Project vessel operation as follows:

- main FSRU generators operating at maximum load;

- maximum SCV operation;
- maximum operation of FSRU auxiliary/emergency equipment;
- LNG carrier, docked at the FSRU, supplying power for LNG pumping and auxiliary equipment;
- supply tugs on standby in safety zone; and
- crewboat travel between onshore and the FSRU.

A summary of operational parameters for natural gas-fueled sources is presented in Table 1. A summary of operational parameters for diesel-fueled sources is presented in Table 2. Stack parameters matched those in *California Environmental Quality Act Air Quality Impact Assessment of the BHP Cabrillo Deepwater Port LNG Import Terminal* (Sierra Research 2006) (see Appendix G7-1 of the Final EIS/EIR).

3.2 Emission Rates

Except for diesel particulate matter (DPM), maximum hourly TAC emission rates and average annual TAC emission rates were developed for each source. As there are no acute health risk indicators currently identified for DPM, only average annual DPM emission rates were used in this analysis.

The average annual DPM emission rates for diesel-fueled equipment were set equal to the corresponding average annual PM₁₀ emission rates for diesel-fueled equipment outlined in *California Environmental Quality Act Air Quality Impact Assessment of the BHP Cabrillo Deepwater Port LNG Import Terminal* (Sierra Research 2006). The engines of the main FSRU generators and LNG carriers would be powered primarily by natural gas. However, a small percentage of fuel for these engines would be diesel in pilot burners (0.6% for FSRU generators and 0.8% for LNG carriers). Emission specifications for dual-fuel Wartsila engines (Wartsila 2006) indicate that particulates would be emitted at a rate of approximately double for diesel fuel as compared to natural gas. Thus, average annual DPM emission rates for main FSRU generators and LNG carriers were estimated by multiplying the average annual PM₁₀ emission rates for these devices (as listed in *California Environmental Quality Act Air Quality Impact Assessment of the BHP Cabrillo Deepwater Port LNG Import Terminal* [Sierra Research 2006]) by factors of 1.4% and 1.9%, respectively.

Non-DPM TAC emission rates were calculated based on fuel input, published emission factors, and, as appropriate, pollution control efficiencies. Non-DPM TAC emission factors for natural gas-fueled equipment and diesel-fueled equipment are presented in Table 3 and Table 4, respectively. Maximum hourly TAC emission rates and average annual TAC emission rates for natural gas-fueled internal combustion equipment are summarized in Tables 5 and 6, respectively. Maximum hourly and average annual TAC emission rates for natural gas-fueled external combustion equipment (SCVs) are summarized in Table 7. Maximum hourly TAC emission rates and average annual TAC emission rates for diesel-fueled internal combustion equipment are summarized in Tables 8 and 9, respectively.

3.3 Receptors

Chronic and acute health risks were evaluated at onshore locations in a receptor grid extending from the shoreline between Oxnard and Malibu. The onshore receptor grid matched the onshore receptor grid for this area presented in *California Environmental Quality Act Air Quality Impact Assessment of the BHP Cabrillo Deepwater Port LNG Import Terminal* (Sierra Research 2006).

3.4 Meteorological Data

The OCD model was run with one year (Calendar Year 2000) of meteorological data from Buoy Station 46025. The Calendar Year 2000 overland and overwater meteorological data sets used were identical to those described in *California Environmental Quality Act Air Quality Impact Assessment of the BHP Cabrillo Deepwater Port LNG Import Terminal* (Sierra Research 2006).

3.5 Model Runs

The OCD input files used for the revised health risk analysis were modified from the OCD input files prepared by the Applicant for the *California Environmental Quality Act Air Quality Impact Assessment of the BHP Cabrillo Deepwater Port LNG Import Terminal* (Sierra Research 2006).

Since source type would have a different TAC/DPM profile, seven sets of OCD model runs were performed to calculate maximum 1-hour ambient concentrations (3 run sets) and annual average ambient concentrations (4 run sets):

Maximum 1-Hour Impact Runs

- Maximum Hourly Non-DPM TAC Emission Rates for Natural Gas-Fueled Internal Combustion Sources
- Maximum Hourly Non-DPM TAC Emission Rate for Natural Gas-Fueled External Combustion Sources (SCVs)
- Maximum Hourly Non-DPM TAC Emission Rates for Diesel-Fueled Internal Combustion Sources

Maximum Annual Average Impact Runs

- Average Annual Non-DPM TAC Emission Rates for Natural Gas-Fueled Internal Combustion Sources
- Average Annual Non-DPM TAC Emission Rate for Natural Gas-Fueled External Combustion Sources (SCVs)
- Average Annual Non-DPM TAC Emission Rates for Diesel-Fueled Internal Combustion Sources
- Average Annual DPM Emission Rates for Diesel-Fueled Internal Combustion Sources

Non-DPM TAC model runs were based on the total emission rate of all non-DPM TACs. The overall impact from the OCD model was then proportioned into each individual TAC accordingly.

4 RISK AND HAZARD

Cancer risk was evaluated by calculating the cumulative maximum individual cancer risk (MICR) of all TACs emitted from Project sources. Non-cancer acute and chronic health risks were evaluated by calculating the cumulative chronic hazard index (HIC) and cumulative acute hazard index (HIA) of all TACs emitted from Project sources. The MICR, HIC, and HIA for each individual TAC were estimated using calculation procedures outlined in *Risk Assessment Procedures for Rules 1401 and 212* (SCAQMD 2005) and *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* (OEHHA 2003). The equations used to calculate MICR, HIC, and HIA are described below.

$$\text{MICR} = \text{CP} \times \text{AveConc} \times \text{AF}_{\text{annual}} \times \text{DBR} \times \text{EVF} \times \text{MP}_{\text{cancer}} \times 10^{-6} \quad (\text{Eq 1})$$

$$HIC = (\text{AveConc} \times MP_{\text{chronic}}) / \text{Chronic REL} \quad (\text{Eq 2})$$

$$HIA = \text{PeakConc} / \text{Acute REL} \quad (\text{Eq 3})$$

Where:

CP = cancer potency factor (mg/kg-day^{-1})

AveConc = average annual concentration ($\mu\text{g/m}^3$)

AF_{annual} = annual adjustment factor

DBR = daily breathing rate (l/kg body weight-day)

EVF = exposure value factor

MP_{cancer} = multi-pathway factor [cancer]

Chronic REL = chronic reference exposure level ($\mu\text{g/m}^3$)

MP_{chronic} = multi-pathway factor [chronic]

PeakConc = maximum 1-hr average concentration ($\mu\text{g/m}^3$)

Acute REL = chronic reference exposure level ($\mu\text{g/m}^3$)

The values of CP, MP_{cancer}, Chronic REL, MP_{chronic}, and Acute REL are unique to each individual TAC. Acute REL and Chronic REL are used as indicators of potential adverse non-cancer health effects. For this analysis, RELs are concentration levels, analogous to an inhalation reference concentration, at which no noncancer adverse health effects are anticipated. CP is a measure of the cancer potency of a carcinogen and is analogous to an inhalation slope factor. When available, RELs and CPs are obtained from OEHHA. REL and CP values were not available from OEHHA for some of the individual PAHs. The REL and CP values for these PAHs were based on inhalation reference doses and slope factors obtained from USEPA Region 9 Preliminary Remediation Goal (PRG) Tables (USEPA 2004).

MICR and HIC were calculated by assuming all receptors were categorized as residential/sensitive. Thus, the values of AF_{annual}, DBR, EVF, MP_{cancer}, and MP_{chronic} were set accordingly.

The values for AF_{annual}, DBR, and EVF are listed in Table 10. The values for CP and MP_{cancer} are listed in Table 12. The values for Chronic REL and MP_{chronic} are listed in Table 13. The values for Acute REL are listed in Table 14.

5 RESULTS

A summary of the maximum 1-hour concentrations for total non-DPM TACs and the annual average concentrations (AveConc) for DPM and total non-DPM TACs predicted from OCD runs is presented in Table 11. Annual average concentrations (AveConc) for individual TACs were calculated from these model results (see Tables 12 and 13). Maximum 1-hour concentrations (PeakConc) for individual TACs were also calculated from these model results (see Table 14).

Summaries of the individual and cumulative MICR, HIC, and HIA due to Project operational emissions are presented in Table 12, Table 13, and Table 14, respectively. The maximum cumulative MICR was estimated at 1.81×10^{-7} , which is less than the significance risk level threshold of an additional cancer risk of 1×10^{-5} . The maximum cumulative HIC was estimated at 0.0045, which is less than the threshold of 1. The maximum cumulative HIA was estimated at 1.33, which is greater than the threshold of 1.

6 DISCUSSION

A health risk analysis was performed to assess potential chronic and acute health risks at onshore locations due to TAC emissions from normal operation of FSRU and Project vessels. The analysis predicts that the exposure to air toxics from operational activities would result in a MICR of 1.81×10^{-7} and a maximum HIC of 0.0045. These values are less than the health risk criteria for additional cancer risk of 1×10^{-5} and the chronic non-cancer hazard index criteria of and 1. Therefore, the potential risks associated with chronic exposure to TAC emissions from Project operations are assumed to be insignificant.

The analysis indicates that the exposure to air toxics would result in a maximum acute hazard index (HIA) of 1.33. Emissions that cause impacts with a cumulative HIA of 1 or greater have the potential for causing adverse impacts. Thus, the maximum impact is predicted to exceed the health risk criteria by 33%.

An examination of OCD model results indicates that impacts would exceed a HIA of 1 only in unpopulated areas between Point Mugu and Point Dume at elevations of at least 200 feet and no more than 2 miles inland (equivalent to a total area of about 3 square miles). The area is part of the Santa Monica Mountains and does not have any residential development but is expected to include recreational activity. The model predicts that for about 95% of this area impacts would exceed a HIA of 1 for no more than 1 to 2 hours per year. The analysis further predicts that for the remaining 5% of this area (about 0.15 square miles), the HIA would exceed 1 for no more than 3 to 4 hours per year.

The risk analysis was based on the assumption that FSRU main generators would operate at maximum load and the LNG carrier unloading operations would occur for 24 hours/day, 365 days per year (8,760 hours per year). However, the FSRU main generators would, on an average annual basis, operate at approximately half of maximum load; and the LNG carrier would be docked at the FSRU for approximately 1,700 hours per year (with 1,200 hours per year of LNG pumping).

Approximately 98% of the total HIA predicted in this analysis can be attributed to emissions of acrolein from natural gas-fueled internal combustion engines (i.e., FSRU main generators and LNG carriers). The acute REL for acrolein of $0.19 \mu\text{g}/\text{m}^3$, which is used to calculate the HIA in this analysis, was developed by OEHHA to be protective of mild adverse effects, i.e., eye irritation (OEHHA 1999). The lowest observed adverse effect level (LOAEL) for eye irritation in healthy human volunteers is exposure to $140 \mu\text{g}/\text{m}^3$ (0.06 ppm) acrolein for five minutes. The acute REL was developed from the LOAEL by applying a time-weighted average factor of 6 to the LOAEL and an additional cumulative uncertainty factor of 60. OEHHA acknowledges there is significant uncertainty in the acute REL for acrolein due to the lack of a no observed adverse effects level (NOAEL) and a short exposure duration in the study for LOAEL (OEHHA 1999).

The acute REL for acrolein developed by OEHHA is significantly lower than acute dose-response values used by various Federal agencies for acrolein. USEPA provided a comparison of acute dose-response values (USEPA 2005). A summary of that comparison for acute exposure levels for acrolein is provided below (in increasing order of value):

OEHHA Acute REL	0.19 µg/m ³	Mild adverse impacts for 1-hour exposures.
ATSDR MRL	6.9 µg/m ³	Minimal risk level for no adverse effects for 1 to 14-day exposure. Draft value (ATSDR 2005).
AEGL-1	69 µg/m ³	Acute exposure guideline level for mild effects for 1-hour exposures. Level is interim.
AEGL-2	230 µg/m ³	Acute exposure guideline level for moderate effects for 1-hour exposures. Level is interim.
ERPG-1	230 µg/m ³	US Department of Energy Emergency Removal Program guidelines for mild and transient effects for 1-hour exposures.
IDLH/10	460 µg/m ³	One-tenth of levels determined by NIOSH to be imminently dangerous to life and health, approximately comparable to mild effects levels for 1-hour exposures.

Key:

ATSDR = Agency for Toxic Substances and Disease Registry (US Dept of Health and Human Services)

If any of these other acute dose-response values were used for acrolein, the cumulative HIA would be less than 0.1. Due to the predicted infrequency of potential exceedences of HIA, the location of potential exceedences of HIA, the conservative assumptions used in the dispersion modeling, and the general conservative nature of the Acute REL for acrolein developed by OEHHA, it is concluded that acute impacts from Project operational activities would not expose the public or sensitive receptors to substantial pollutant concentrations.

7 REFERENCES

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Wartsila. 2006. Emission Data for 50DF Engines.

Table 1
Natural Gas-Fueled Sources

Parameter	Units	Internal Combustion Sources			External Combustion Sources	
		Main Gen ^a	LNG Carrier ^{b,c}			
			Pump	Aux		
Maximum Power	kW	-	4477	1946	21120	
Average Power	kW	-	3733	1946	15840	
Maximum Hourly Heat Input	MMBtu/hr	65.7	38.2	16.6	180.2	
Average Hourly Heat Input	MMBtu/hr	33.6	31.9	16.6	135.2	
Annual Hours of Operation	hr/yr	8760	1139	1634	436	
					8760	

Key:

FW3 = Federal Waters between FSRU and California Coastal Water boundary

Pump = Engine use due to LNG Pumping @ FSRU

Aux = Engine use due to auxiliary systems @ FSRU

Notes:

- a. Data for each generator.
- b. For LNG carrier operation in FW3, maximum power based on 210,000 m³ LNG carrier operating @ 48% load and average power based on 138,000 m³ LNG carrier operating @ 48% load.
- c. Hours of Operation: LNGC Pump based on 99 berthing x 11.5 hrs/berthing; LNGC Aux based on 99 berthing x 16.5 hrs/berthing; LNGC FW3 based on 99 roundtrips x 4.4 hrs/roundtrip
- d. Data for each SCV. Maximum Hourly Heat Input assumes operation of 8 SCVs. Average Hourly Heat Input assumes operation of 4 SCVs.

Table 2
Diesel-Fueled Sources

Parameter	Units	FSRU Equipment					Supply Tug				Crewboat ^b			LNG Carrier ^c		
		Main Gen ^a	Backup Gen	Emer Gen	Fire Pump	Life Boat	DW	FW1	FW2	FW3	DW	FW1	FW2	Pump	Aux	FW3
Maximum Power	MW	-	-	-	-	-	-	-	2.58	-	0.52	1.1	-	-	-	-
Annual Power	MW-hr	-	-	-	-	-	177	1205	19340	1639	54	424	243	-	-	-
Maximum Hourly Heat Input	MMBtu/hr	0.39	66.3	35.84	5.85	0.64	-	-	23.7	-	4.8	10.1	-	0.31	0.13	-
Average Hourly Heat Input	MMBtu/hr	0.20	-	-	-	-	-	-	-	-	-	-	-	0.25	0.13	1.08
Maximum Fuel Rate	gal/hr	2.9	484	262	43	4.7	-	-	173	-	17	37	-	2.2	1.0	-
Annual Hours of Operation	hr/yr	8760	-	-	-	-	-	-	-	-	-	-	-	1139	1634	436
Annual Fuel Consumption	gal/yr	12888	48417	26152	4270	232	11,871	80,814	1,297,049	109,921	3,622	28,436	16,297	2118	1584	3440

Key:

DW = District Waters

FW1 = Federal Waters between FSRU Safety Zone and District Waters

FW2 = Federal Waters in FSRU Safety Zone

FW3 = Federal Waters between FSRU and California Coastal Water boundary

Pump = Engine use due to LNG Pumping @ FSRU

Aux = Engine use due to auxiliary systems @ FSRU

Notes:

a. Data for each main generator. Diesel usage based on assumption of 0.06% diesel fuel pilot.

b. Maximum 1-hour fuel rate of crewboat in DW and FW1 adjusted to account for operation of only 0.5 hour in each area per 1-hour period.

c. Diesel usage based on assumption of 0.08% diesel fuel pilot.

Table 3
TAC Emission Factors for Natural Gas Equipment

Pollutant	Natural Gas Fired External Combustion Equipment ^{1,2} [Uncontrolled] (lb/MMcf)	Natural Gas Fired Internal Combustion Equipment ³ [Uncontrolled] (lb/MMBtu)
benzene	0.0021	0.000440
formaldehyde	0.075	0.0528
unspecified PAHs	0.0000882	
2-methylnaphthalene		0.0000332
acenaphthene		0.00000125
acenaphthylene		0.000005530
benzo(b)fluoranthene		0.000000166
benzo(e)pyrene		0.000000415
benzo(g,h,i)perylene		0.000000414
chrysene		0.000000693
fluoranthene		0.000000111
fluorene		0.000005670
phenanthrene		0.000010400
pyrene		0.000001360
naphthalene	0.00061	0.0000744
1,3-butadiene		0.000267
acetaldehyde	0.0031	0.00836
acrolein	0.0027	0.00514
propylene	0.53	
toluene	0.0265	0.000408
xylanes	0.0197	0.000184
ethyl benzene	0.0069	0.0000397
hexane	0.0046	0.00111
carbon tetrachloride		0.0000367
chlorobenzene		0.0000304
chloroform		0.0000285
ethylene dibromide		0.0000443
methanol		0.0025
methylene chloride		0.00002
phenol		0.000024
styrene		0.0000236
tetrachloroethane		0.00000248
vinyl chloride		0.0000149
TOTAL	0.671	0.072

References:

1. USEPA, July 1998, AP-42 Section 1.4, Table 1.4-3: benzene, formaldehyde, naphthalene, and PAHs (excluding naphthalene).
2. VCPACD, May 2001, AB 2588 Combustion Emission Factors: all pollutants except benzene, formaldehyde, naphthalene, and PAHs (excluding naphthalene).
3. USEPA, August , AP-42 Section 3.2, Table 3.2-2.

Table 4
TAC Emission Factors for Diesel Internal Combustion Equipment

Pollutant	Emission Factor ^{a,b} (lb/1000-gal)	PAH Fracation ^c (%)
Benzene	0.1863	-
Toluene	0.1054	-
Xylenes	0.0424	-
acenaphthene ^b	0.00062	1.71%
acenaphthylene ^b	0.00220	6.08%
anthracene ^b	0.00081	2.25%
benz(a)anthracene ^b	0.00073	2.02%
benzo(a)pyrene ^b	0.00008	0.23%
benzo(b)fluoranthene ^b	0.00004	0.12%
benzo(g,h,i)perylene ^b	0.00021	0.59%
benzo(k)fluoranthene ^b	0.00007	0.19%
chrysene ^b	0.00015	0.42%
dibenz(a,h)anthracene ^b	0.00025	0.70%
fluoranthene ^b	0.00331	9.14%
fluorene ^b	0.01270	35.07%
indeno(1,2,3-cd)pyrene ^b	0.00016	0.45%
phenanthrene ^b	0.01278	35.31%
pyrene ^b	0.00208	5.74%
Naphthalene	0.0197	-
Chlorobenzene	0.0002	-
Hexane	0.0269	-
Ethyl Benzene	0.0109	-
Hydrogen Chloride	0.1863	-
Arsenic	0.0016	-
Cadmium	0.0015	-
Total Chromium	0.0006	-
Hexavalent Chromium	0.0001	-
Copper	0.0041	-
Lead	0.0083	-
Manganese	0.0031	-
Mercury	0.0020	-
Nickel	0.0039	-
Selenium	0.0022	-
Zinc	0.0224	-
Propylene	0.4670	-
Formaldehyde	1.7261	-
Acetaldehyde	0.7833	-
Acrolein	0.0339	-
1,3-Butadiene	0.2174	-
TOTAL	3.8918	-

Notes:

- a. Emission factors from [AB 2588 Combustion Emission Factors](#) (VCPACD, May 2001).
- b. Emission Factor for each specific PAH = Total PAH (w/o naphthalene) Emission Factor (0.0362 lb/1000-gal) x PAH Fraction. [Emission factor for Total PAH (w/o naphthalene) from AB 2588 Combustion Emission Factors (VCPACD, May 2001).]
- c. PAH Fraction based on emission factors of speciated PAHs (w/o naphthalene) in Section 3.3, Table 3.3-2 of [AP-42 Volume 1](#) (EPA 1995)

Table 5
Maximum Hourly Emission Rates for Natural Gas Internal Combustion Sources

Pollutant	Emissions (g/s)			
	Main Gen ^a	LNG Carrier		TOTAL
		Pump	Aux	
benzene	2.368E-03	2.118E-03	9.206E-04	1.014E-02
formaldehyde	1.311E-01	2.542E-01	1.105E-01	7.580E-01
2-methylnaphthalene	1.786E-04	1.598E-04	6.946E-05	7.652E-04
acenaphthene	6.726E-06	6.017E-06	2.615E-06	2.881E-05
acenaphthylene	2.976E-05	2.662E-05	1.157E-05	1.275E-04
benzo(b)fluoranthene	8.932E-07	7.990E-07	3.473E-07	3.826E-06
benzo(e)pyrene	2.233E-06	1.998E-06	8.683E-07	9.565E-06
benzo(g,h,i)perylene	2.228E-06	1.993E-06	8.662E-07	9.542E-06
chrysene	3.729E-06	3.336E-06	1.450E-06	1.597E-05
fluoranthene	5.973E-07	5.343E-07	2.322E-07	2.558E-06
fluorene	3.051E-05	2.729E-05	1.186E-05	1.307E-04
phenanthrene	5.596E-05	5.006E-05	2.176E-05	2.397E-04
pyrene	7.318E-06	6.546E-06	2.845E-06	3.135E-05
naphthalene	4.003E-04	3.581E-04	1.557E-04	1.715E-03
1,3-butadiene	6.631E-04	1.285E-03	5.586E-04	3.833E-03
acetaldehyde	2.076E-02	4.024E-02	1.749E-02	1.200E-01
acrolein	1.276E-02	2.474E-02	1.075E-02	7.379E-02
toluene	2.195E-03	1.964E-03	8.536E-04	9.404E-03
xylenes	9.901E-04	8.857E-04	3.850E-04	4.241E-03
ethyl benzene	2.136E-04	1.911E-04	8.306E-05	9.150E-04
hexane	5.973E-03	5.343E-03	2.322E-03	2.558E-02
carbon tetrachloride	1.975E-04	1.767E-04	7.679E-05	8.459E-04
chlorobenzene	1.636E-04	1.463E-04	6.360E-05	7.007E-04
chloroform	1.534E-04	1.372E-04	5.963E-05	6.569E-04
ethylene dibromide	2.384E-04	2.132E-04	9.269E-05	1.021E-03
methanol	1.345E-02	1.203E-02	5.231E-03	5.762E-02
methylene chloride	1.076E-04	9.627E-05	4.185E-05	4.610E-04
phenol	1.291E-04	1.155E-04	5.021E-05	5.532E-04
styrene	1.270E-04	1.136E-04	4.938E-05	5.439E-04
tetrachloroethane	1.334E-05	1.194E-05	5.189E-06	5.716E-05
vinyl chloride	8.017E-05	7.172E-05	3.117E-05	3.434E-04
TOTAL	1.924E-01	3.447E-01	1.498E-01	1.072E+00

Key:

Pump = Engine use due to LNG Pumping @ FSRU

Aux = Engine use due to auxiliary systems @ FSRU

Notes:

- a. Data for each main generator. A 70% control efficiency assumed for formaldehyde, acetaldehyde, and acrolein; and a 35% control efficiency for all other

Table 6
Average Annual Emission Rates for Natural Gas Internal Combustion Sources

Pollutant	Emissions (g/s)					
	Main Gen^a	LNG Carrier	Pump	Aux	FW3	TOTAL
benzene	1.211E-03	2.296E-04	1.717E-04	3.730E-04	4.407E-03	
formaldehyde	6.706E-02	2.755E-02	2.061E-02	4.476E-02	2.941E-01	
2-methylnaphthalene	9.136E-05	1.733E-05	1.296E-05	2.814E-05	3.325E-04	
acenaphthene	3.440E-06	6.523E-07	4.878E-07	1.060E-06	1.252E-05	
acenaphthylene	1.522E-05	2.886E-06	2.158E-06	4.687E-06	5.538E-05	
benzo(b)fluoranthene	4.568E-07	8.663E-08	6.478E-08	1.407E-07	1.663E-06	
benzo(e)pyrene	1.142E-06	2.166E-07	1.620E-07	3.518E-07	4.156E-06	
benzo(g,h,i)perylene	1.139E-06	2.160E-07	1.616E-07	3.509E-07	4.146E-06	
chrysene	1.907E-06	3.616E-07	2.705E-07	5.874E-07	6.941E-06	
fluoranthene	3.055E-07	5.793E-08	4.332E-08	9.409E-08	1.112E-06	
fluorene	1.560E-05	2.959E-06	2.213E-06	4.806E-06	5.679E-05	
phenanthrene	2.862E-05	5.427E-06	4.059E-06	8.815E-06	1.042E-04	
pyrene	3.743E-06	7.097E-07	5.308E-07	1.153E-06	1.362E-05	
naphthalene	2.047E-04	3.883E-05	2.904E-05	6.306E-05	7.451E-04	
1,3-butadiene	3.391E-04	1.393E-04	1.042E-04	2.263E-04	1.487E-03	
acetaldehyde	1.062E-02	4.363E-03	3.263E-03	7.086E-03	4.657E-02	
acrolein	6.528E-03	2.682E-03	2.006E-03	4.357E-03	2.863E-02	
toluene	1.123E-03	2.129E-04	1.592E-04	3.458E-04	4.086E-03	
xylenes	5.063E-04	9.602E-05	7.181E-05	1.560E-04	1.843E-03	
ethyl benzene	1.092E-04	2.072E-05	1.549E-05	3.365E-05	3.976E-04	
hexane	3.055E-03	5.793E-04	4.332E-04	9.409E-04	1.112E-02	
carbon tetrachloride	1.010E-04	1.915E-05	1.432E-05	3.111E-05	3.676E-04	
chlorobenzene	8.366E-05	1.586E-05	1.186E-05	2.577E-05	3.045E-04	
chloroform	7.843E-05	1.487E-05	1.112E-05	2.416E-05	2.854E-04	
ethylene dibromide	1.219E-04	2.312E-05	1.729E-05	3.755E-05	4.437E-04	
methanol	6.880E-03	1.305E-03	9.757E-04	2.119E-03	2.504E-02	
methylene chloride	5.504E-05	1.044E-05	7.805E-06	1.695E-05	2.003E-04	
phenol	6.604E-05	1.252E-05	9.366E-06	2.034E-05	2.404E-04	
styrene	6.494E-05	1.232E-05	9.210E-06	2.000E-05	2.364E-04	
tetrachloroethane	6.825E-06	1.294E-06	9.679E-07	2.102E-06	2.484E-05	
vinyl chloride	4.100E-05	7.776E-06	5.815E-06	1.263E-05	1.492E-04	
TOTAL	9.842E-02	3.737E-02	2.795E-02	6.070E-02	4.213E-01	

Key:

FW3 = Federal Waters between FSRU and California Coastal Water boundary

Pump = Engine use due to LNG Pumping @ FSRU

Aux = Engine use due to auxiliary systems @ FSRU

Notes:

- a. Data for each main generator. A 70% control efficiency assumed for formaldehyde, acetaldehyde, and acrolein; and a 35% control efficiency for all other pollutants.

Table 7
Emission Rates for Natural Gas External Combustion Sources (SCVs)

Pollutant	Maximum Hourly Emission Rate ^{a,b} (g/s)	Annual Average Emission Rate ^{a,c} (g/s)
benzene	2.830E-05	3.019E-05
formaldehyde	1.011E-03	1.078E-03
unspecified PAHs	1.188E-06	1.268E-06
naphthalene	8.220E-06	8.769E-06
acetaldehyde	4.177E-05	4.456E-05
acrolein	3.638E-05	3.881E-05
propylene	7.142E-03	7.619E-03
toluene	3.571E-04	3.809E-04
xylenes	2.655E-04	2.832E-04
ethyl benzene	9.298E-05	9.919E-05
hexane	6.199E-05	6.613E-05
TOTAL	9.046E-03	9.650E-03

Notes:

a. Heating value of natural gas is assumed to be 1008 Btu/scf.

b. Maximum hourly emission rate for each of 8 SCVs.

c. Annual average emission rate for each of 4 SCVs.

Table 10
Summary of Risk Analysis Parameters

Parameter	Values	Comments
AF _{ann}	1.0	Sensitive Receptors
DBR	302	Sensitive Receptors
EVF	0.96	Sensitive Receptors

Key:

AF_{annual} = annual adjustment factor

DBR = daily breathing rate

EVF = exposure value factors

Table 11
Summary of OCD Model Results

Source	Pollutant	Maximum 1-hr Concentration [PeakConc] ($\mu\text{g}/\text{m}^3$)	Annual Average Concentration [AveConc] ($\mu\text{g}/\text{m}^3$)
Natural Gas Internal Combustion Sources	Total Non-DPM TAC	3.45	0.00289
Natural Gas External Combustion Sources (SCVs)	Total Non-DPM TAC	0.49	0.00032
Diesel Internal Combustion Sources	Total Non-DPM TAC	0.91	0.00079
	DPM	-	0.00046

Key:

DPM = diesel particulate matter

Non-DPM TAC = toxic air contaminants except DPM

Table 12
Summary of Maximum Cancer Risks

Table 13
Summary Maximum Non-Cancer Chronic Risks

Pollutant	AveConc ($\mu\text{g}/\text{m}^3$)				Chronic REL ^a ($\mu\text{g}/\text{m}^3$)	MP_R	Total HIC
	Nat Gas IC	Nat Gas EC	Diesel IC	TOTAL			
benzene	1.776E-05	1.001E-06	3.84E-05	5.712E-05	60	1.00	9.52E-07
formaldehyde	2.131E-03	3.575E-05	3.49E-04	2.516E-03	3	1.00	8.39E-04
unspecified PAHs		4.204E-08		4.204E-08			
2-methylnaphthalene	1.340E-06			1.340E-06	9	1.00	1.49E-07
acenaphthene	5.045E-08		1.27E-07	1.776E-07	210	1.00	8.46E-10
acenaphthylene	2.232E-07		4.53E-07	6.762E-07	210	1.00	3.22E-09
benzo(b)fluoranthene	6.700E-09		8.87E-09	1.557E-08			
benzo(e)pyrene	1.675E-08		4.38E-08	6.053E-08		1.00	
benzo(g,h,i)perylene	1.671E-08			1.671E-08	105	1.00	1.59E-10
chrysene	2.797E-08		3.16E-08	5.957E-08			
fluoranthene	4.480E-09		6.81E-07	6.858E-07	140	1.00	4.90E-09
fluorene	2.288E-07		2.61E-06	2.843E-06	140	1.00	2.03E-08
phenanthrene	4.197E-07		2.63E-06	3.052E-06	1050	1.00	2.91E-09
pyrene	5.489E-08		4.28E-07	4.828E-07	105	1.00	4.60E-09
anthracene			1.67E-07	1.674E-07	1050	1.00	1.59E-10
benz(a)anthracene			1.50E-07	1.504E-07			
benzo(a)pyrene			1.68E-08	1.683E-08			
benzo(k)fluoranthene			1.39E-08	1.388E-08			
dibenz(a,h)anthracene			5.22E-08	5.219E-08			
indeno(1,2,3-cd)pyrene			3.36E-08	3.357E-08			
naphthalene	3.003E-06	2.908E-07	4.06E-06	7.350E-06	9	1.00	8.17E-07
1,3-butadiene	1.078E-05	0.000E+00	4.48E-05	5.554E-05	20	1.00	2.78E-06
acetaldehyde	3.374E-04	1.478E-06	1.58E-04	4.972E-04	9	1.00	5.52E-05
acrolein	2.074E-04	1.287E-06	6.85E-06	2.156E-04	0.06	1.00	3.59E-03
propylene	0.000E+00	2.526E-04	9.62E-05	3.488E-04	3000	1.00	1.16E-07
toluene	1.647E-05	1.263E-05	2.17E-05	5.080E-05	300	1.00	1.69E-07
xylanes	7.426E-06	9.391E-06	8.73E-06	2.555E-05	700	1.00	3.65E-08
ethyl benzene	1.602E-06	3.289E-06	2.24E-06	7.136E-06	2000	1.00	3.57E-09
hexane	4.480E-05	2.193E-06	5.54E-06	5.253E-05	7000	1.00	7.50E-09
carbon tetrachloride	1.481E-06			1.481E-06	40	1.00	3.70E-08
chlorobenzene	1.227E-06		4.12E-08	1.268E-06	1000	1.00	1.27E-09
chloroform	1.150E-06			1.150E-06	300	1.00	3.83E-09
ethylene dibromide	1.788E-06			1.788E-06	0.8	1.00	2.23E-06
methanol	1.009E-04			1.009E-04	4000	1.00	2.52E-08
methylene chloride	8.072E-07			8.072E-07	400	1.00	2.02E-09
phenol	9.686E-07			9.686E-07	200	1.00	4.84E-09
styrene	9.525E-07			9.525E-07	900	1.00	1.06E-09
tetrachloroethane	1.001E-07			1.001E-07			
vinyl chloride	6.014E-07			6.014E-07			
Hydrogen Chloride			3.71E-05	3.705E-05	9	1.00	4.12E-06
Arsenic			3.18E-07	3.182E-07	0.03	1.91	2.03E-05
Cadmium			2.98E-07	2.983E-07	0.02	1.50	2.24E-05
Total Chromium			1.19E-07	1.193E-07			
Hexavalent Chromium			1.99E-08	1.989E-08	0.2	1.00	9.94E-08
Copper			8.15E-07	8.154E-07			
Lead			1.65E-06	1.651E-06			
Manganese			6.17E-07	6.165E-07	0.2	1.00	3.08E-06
Mercury			3.98E-07	3.978E-07	0.09	10.06	4.45E-05
Nickel			7.76E-07	7.756E-07	0.05	1.00	1.55E-05
Selenium			4.38E-07	4.375E-07	20	1.00	2.19E-08
Zinc			4.45E-06	4.455E-06			
Subtotal	0.00289	0.00032	0.00079	-			0.0045
DPM			0.00046	4.600E-04	5	1.00	0.000092
TOTAL	-	-	-	-	-	-	0.0046

a. Chronic REL from OEHHA TCDB except as noted below:

Acenaphthene, anthracene, fluoranthene, fluorene, and pyrene from Region 9 PRG Table (EPA 2004).

Acenaphthylene based on data for acenaphthene; benzo(g,h,i)perylene based on data for pyrene; phenanthrene: based on data for anthracene.

Table 14
Summary of Maximum Non-Cancer Acute Risks

Pollutant	PeakConc ($\mu\text{g}/\text{m}^3$)				Acute REL ($\mu\text{g}/\text{m}^3$)	Total HIA
	Nat Gas IC	Nat Gas EC	Diesel IC	TOTAL		
benzene	3.264E-02	1.527E-03	4.947E-02	8.364E-02	1300	0.000064
formaldehyde	2.440E+00	5.452E-02	3.660E-01	2.860E+00	94	0.030
unspecified PAHs		6.412E-05		6.412E-05		
2-methylnaphthalene	2.463E-03			2.463E-03		
acenaphthene	9.274E-05		1.639E-04	2.567E-04		
acenaphthylene	4.103E-04		5.841E-04	9.944E-04		
benzo(b)fluoranthene	1.232E-05		1.144E-05	2.376E-05		
benzo(e)pyrene	3.079E-05		5.645E-05	8.724E-05		
benzo(g,h,i)perylene	3.071E-05			3.071E-05		
chrysene	5.141E-05		4.075E-05	9.216E-05		
fluoranthene	8.235E-06		8.785E-04	8.867E-04		
fluorene	4.207E-04		3.371E-03	3.792E-03		
phenanthrene	7.716E-04		3.394E-03	4.166E-03		
pyrene	1.009E-04		5.518E-04	6.527E-04		
anthracene			2.159E-04	2.159E-04		
benz(a)anthracene			1.939E-04	1.939E-04		
benzo(a)pyrene			2.170E-05	2.170E-05		
benzo(k)fluoranthene			1.789E-05	1.789E-05		
dibenz(a,h)anthracene			6.730E-05	6.730E-05		
indeno(1,2,3-cd)pyrene			4.329E-05	4.329E-05		
naphthalene	5.520E-03	4.434E-04	5.231E-03	1.119E-02		
1,3-butadiene	1.234E-02		5.772E-02	7.006E-02		
acetaldehyde	3.863E-01	2.254E-03	1.661E-01	5.547E-01		
acrolein	2.375E-01	1.963E-03	7.189E-03	2.467E-01	0.19	1.30
propylene		3.853E-01	1.240E-01	5.093E-01		
toluene	3.027E-02	1.926E-02	2.799E-02	7.752E-02	37000	0.0000021
xylenes	1.365E-02	1.432E-02	1.126E-02	3.923E-02	22000	0.0000018
ethyl benzene	2.945E-03	5.016E-03	2.894E-03	1.086E-02		
hexane	8.235E-02	3.344E-03	7.142E-03	9.284E-02		
carbon tetrachloride	2.723E-03			2.723E-03	1900	0.0000014
chlorobenzene	2.255E-03		5.310E-05	2.308E-03		
chloroform	2.114E-03			2.114E-03	150	0.000014
ethylene dibromide	3.287E-03			3.287E-03		
methanol	1.855E-01			1.855E-01	28000	0.0000066
methylene chloride	1.484E-03			1.484E-03	14000	0.00000011
phenol	1.781E-03			1.781E-03	5800	0.00000031
styrene	1.751E-03			1.751E-03	21000	0.00000008
tetrachloroethane	1.840E-04			1.840E-04		
v vinyl chloride	1.105E-03			1.105E-03	180000	0.000000006
Hydrogen Chloride			5.943E-02	5.943E-02	2100	0.000028
Arsenic			5.104E-04	5.104E-04	0.19	0.0027
Cadmium			4.785E-04	4.785E-04		
Total Chromium			1.914E-04	1.914E-04		
Hexavalent Chromium			3.190E-05	3.190E-05		
Copper			1.308E-03	1.308E-03	100	0.000013
Lead			2.648E-03	2.648E-03		
Manganese			9.889E-04	9.889E-04		
Mercury			6.380E-04	6.380E-04	1.8	0.00035
Nickel			1.244E-03	1.244E-03	6	0.00021
Selenium			7.018E-04	7.018E-04		
Zinc			7.145E-03	7.145E-03		
TOTAL	3.45	0.488	0.91	-	-	1.33